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Tomiyama et al.

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- (54) **STEERING SYSTEM**
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CPC **B62D 1/184** (2013.01)
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CPC B62D 1/184; B62D 1/195
USPC 74/492, 493; 280/806, 807
See application file for complete search history.

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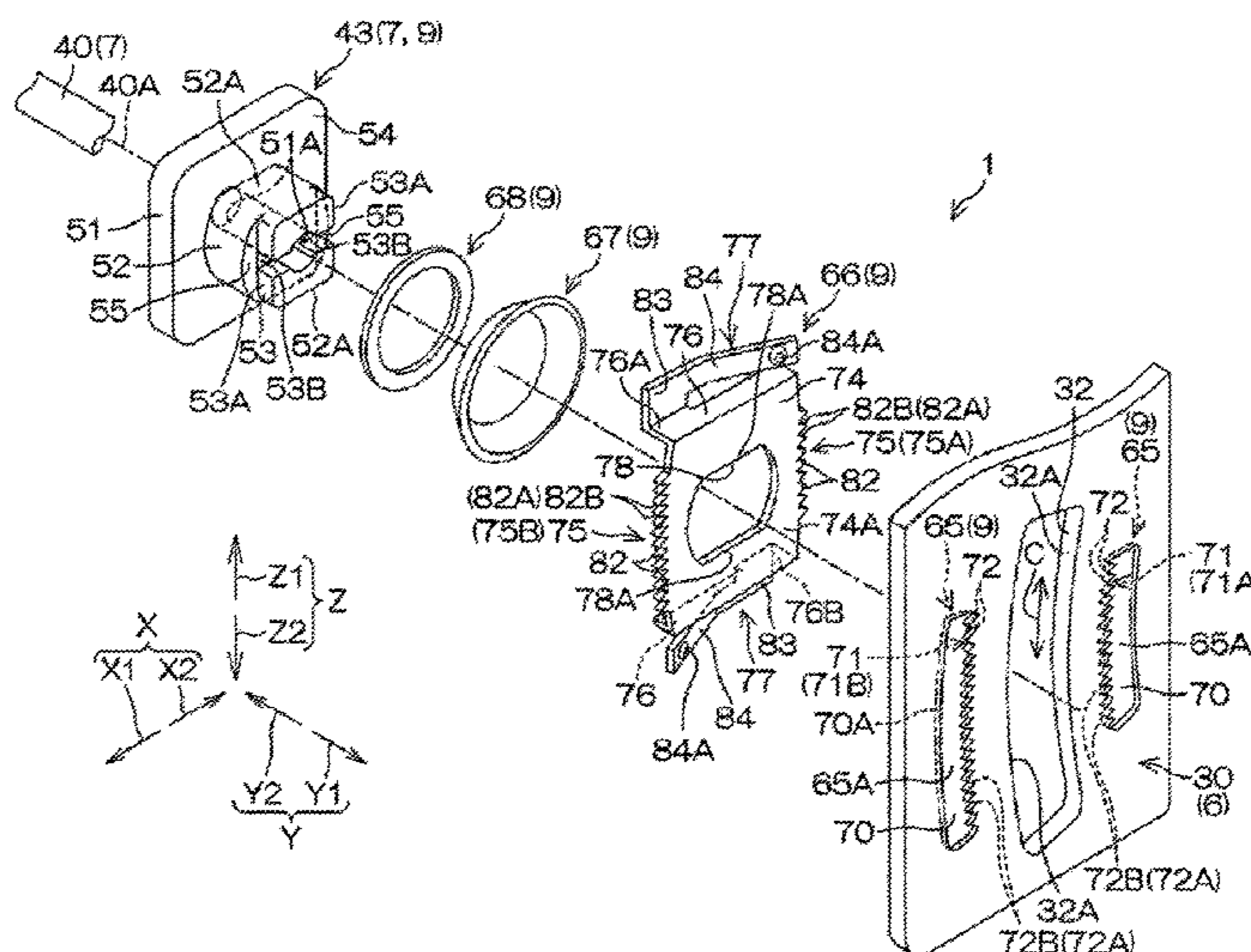
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(57) **ABSTRACT**

In a steering system, a pair of side plates of an upper bracket support first tooth rows each including a plurality of first teeth arranged at a pitch and second tooth rows each including a plurality of second teeth arranged at the pitch. An insertion shaft supports third teeth that can come into and out of contact with the first tooth rows and fourth teeth that can come into and out of contact with the second tooth rows. One pair out of a pair of the tooth tip of each first tooth and the tooth tip of the corresponding second tooth and a pair of the tooth tip of each third tooth and the tooth tip of the corresponding fourth tooth are in the same position in a tilt direction, and the other pair are displaced from each other by a length smaller than the pitch in the tilt direction.

2 Claims, 12 Drawing Sheets



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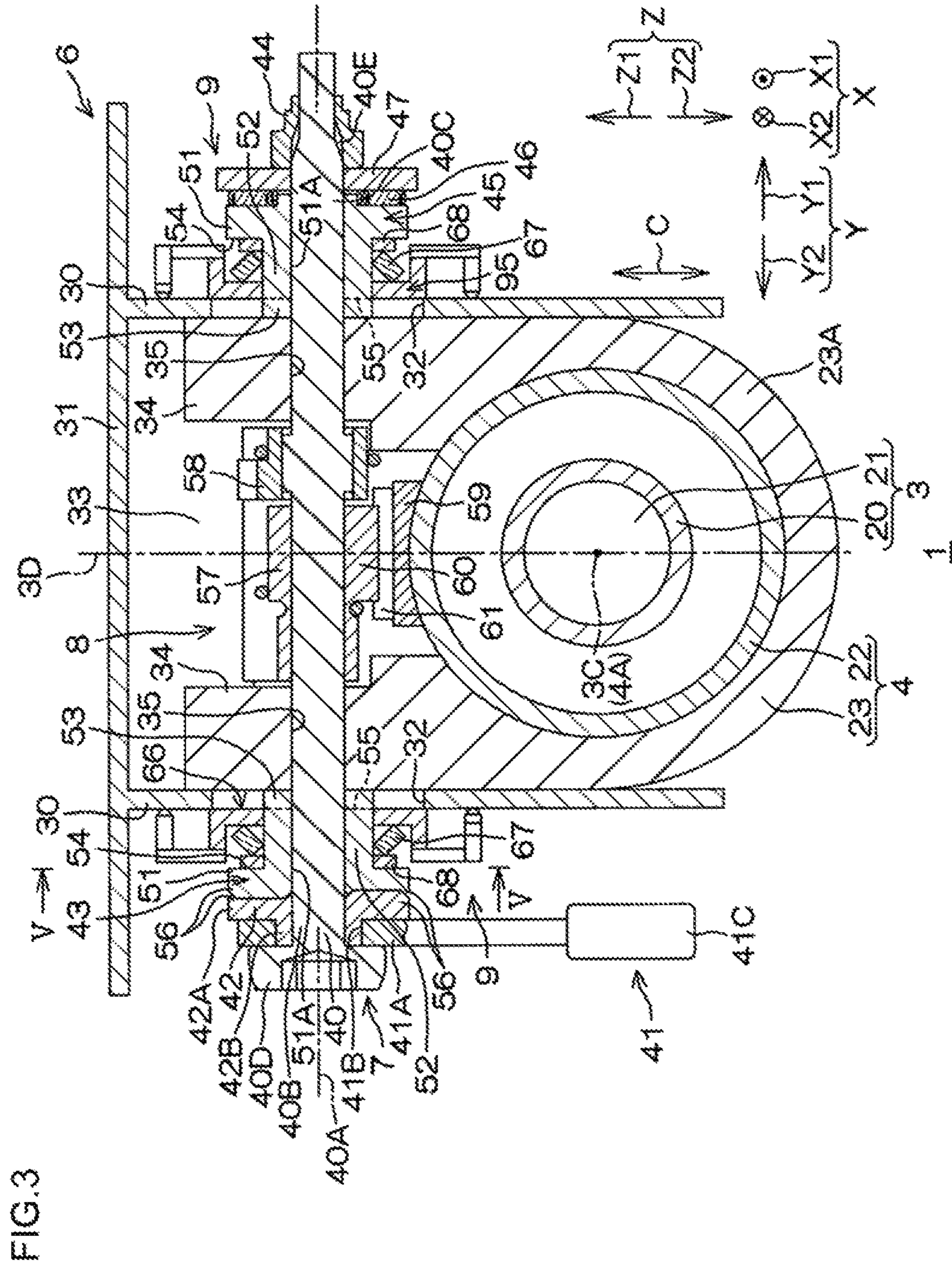


FIG. 4

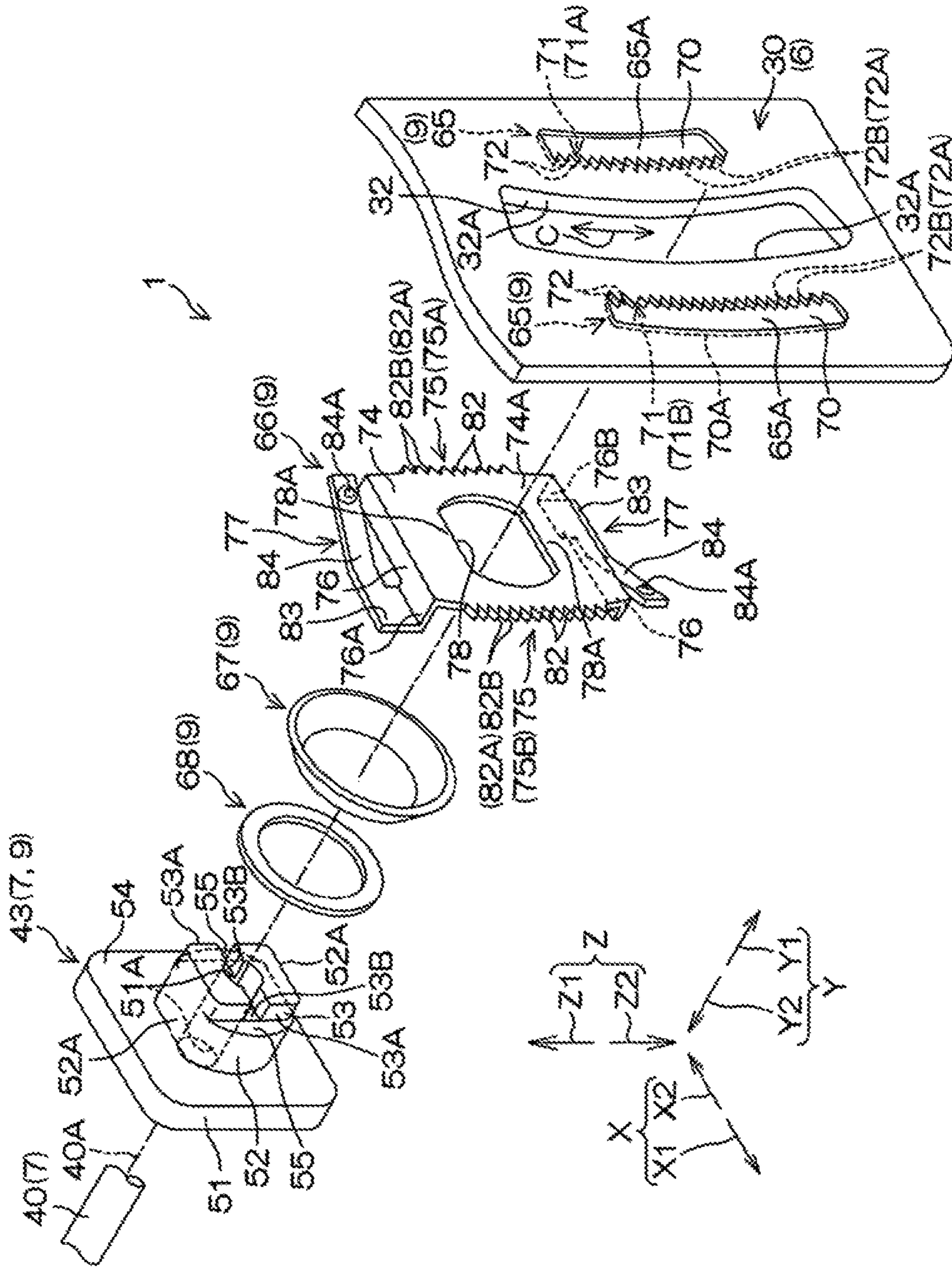


FIG. 5

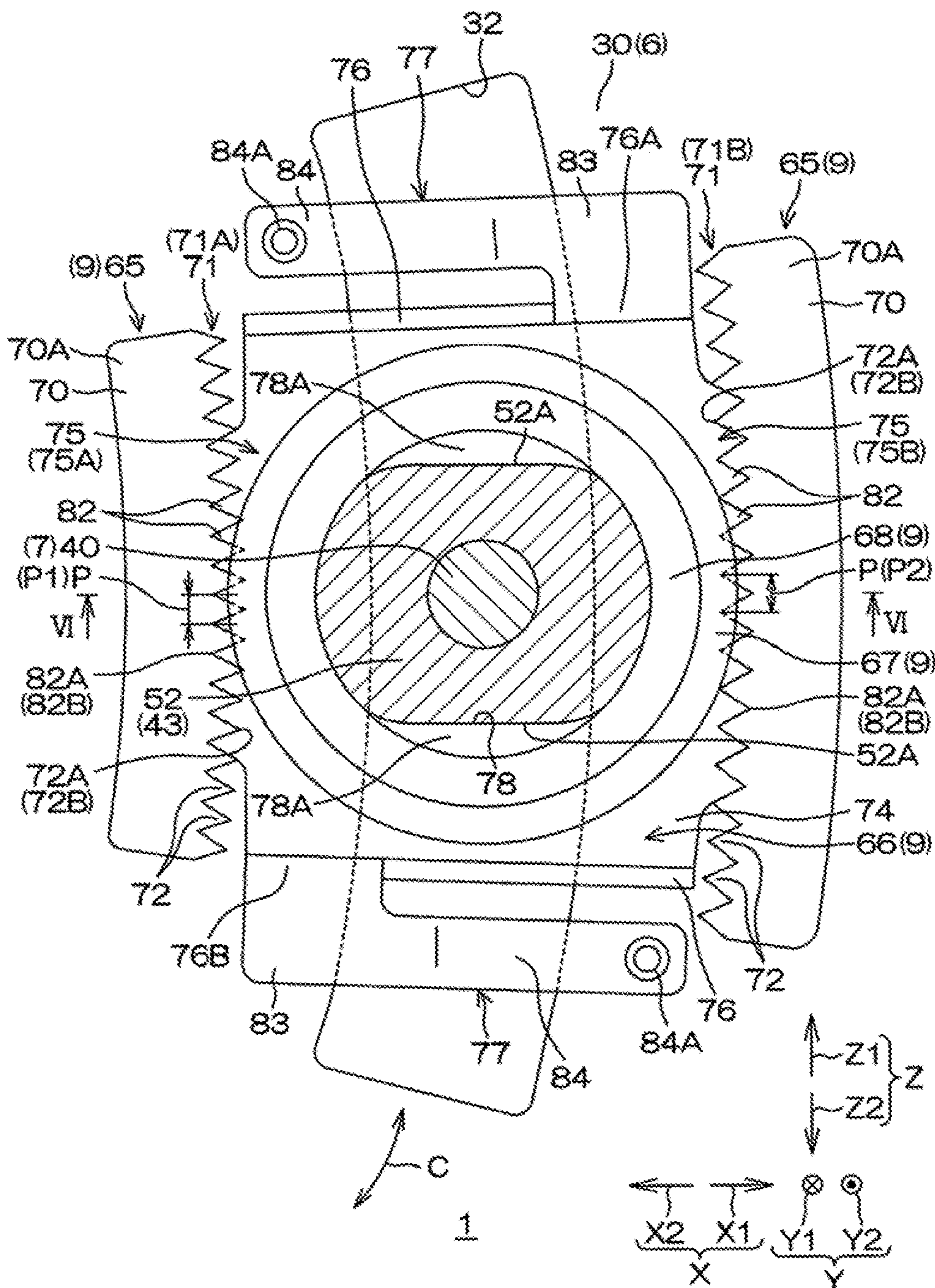


FIG.6

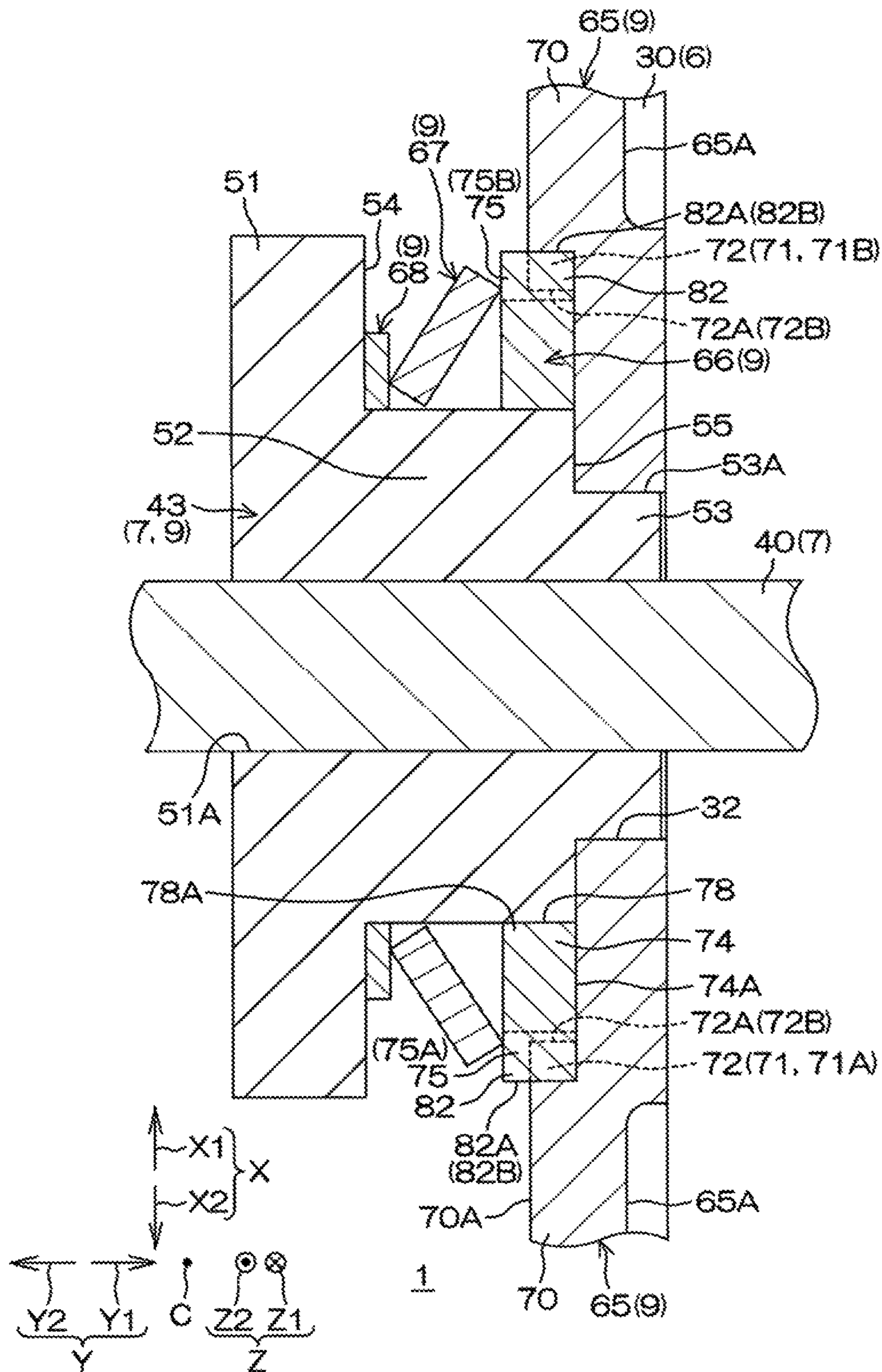


FIG. 7

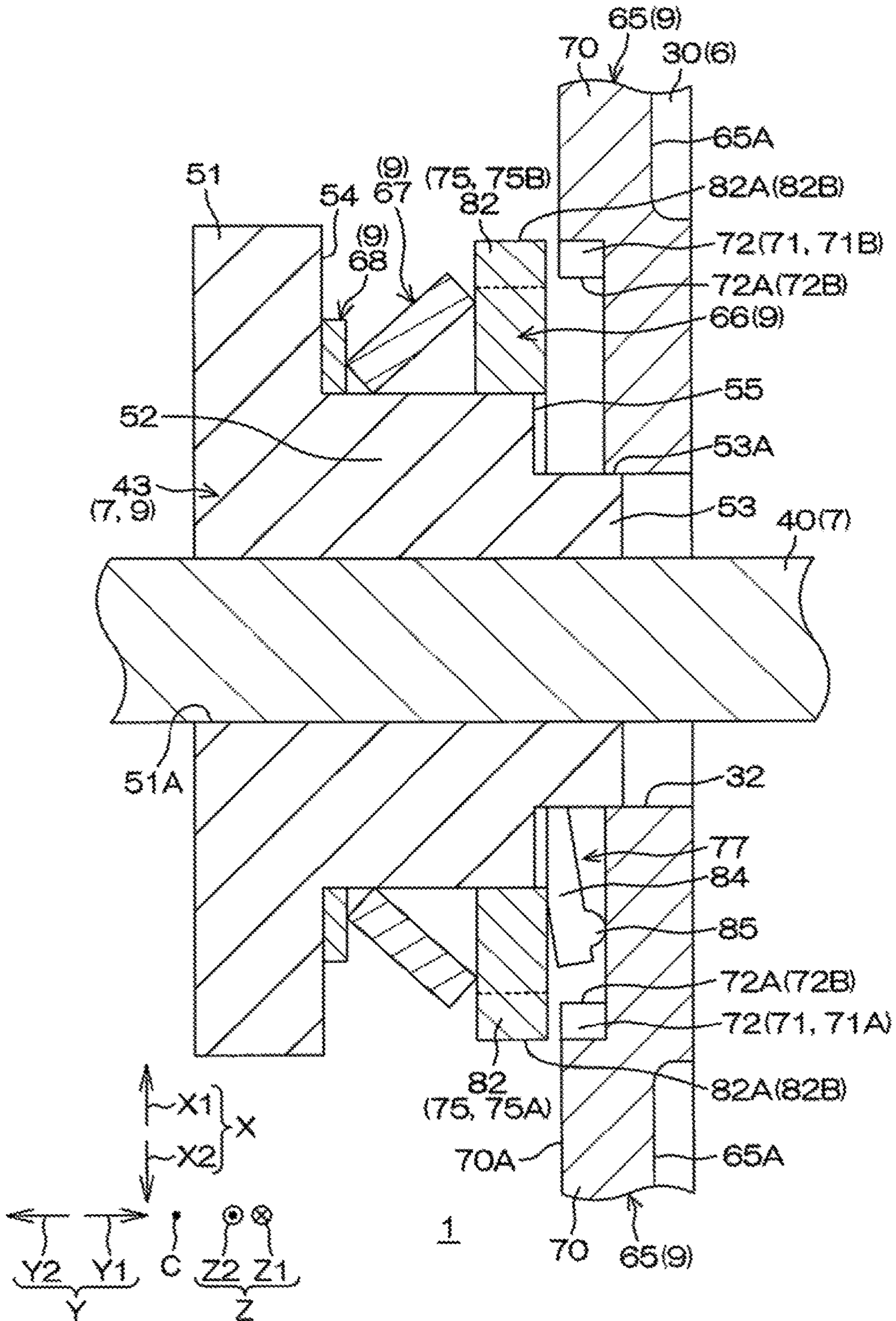


FIG. 8

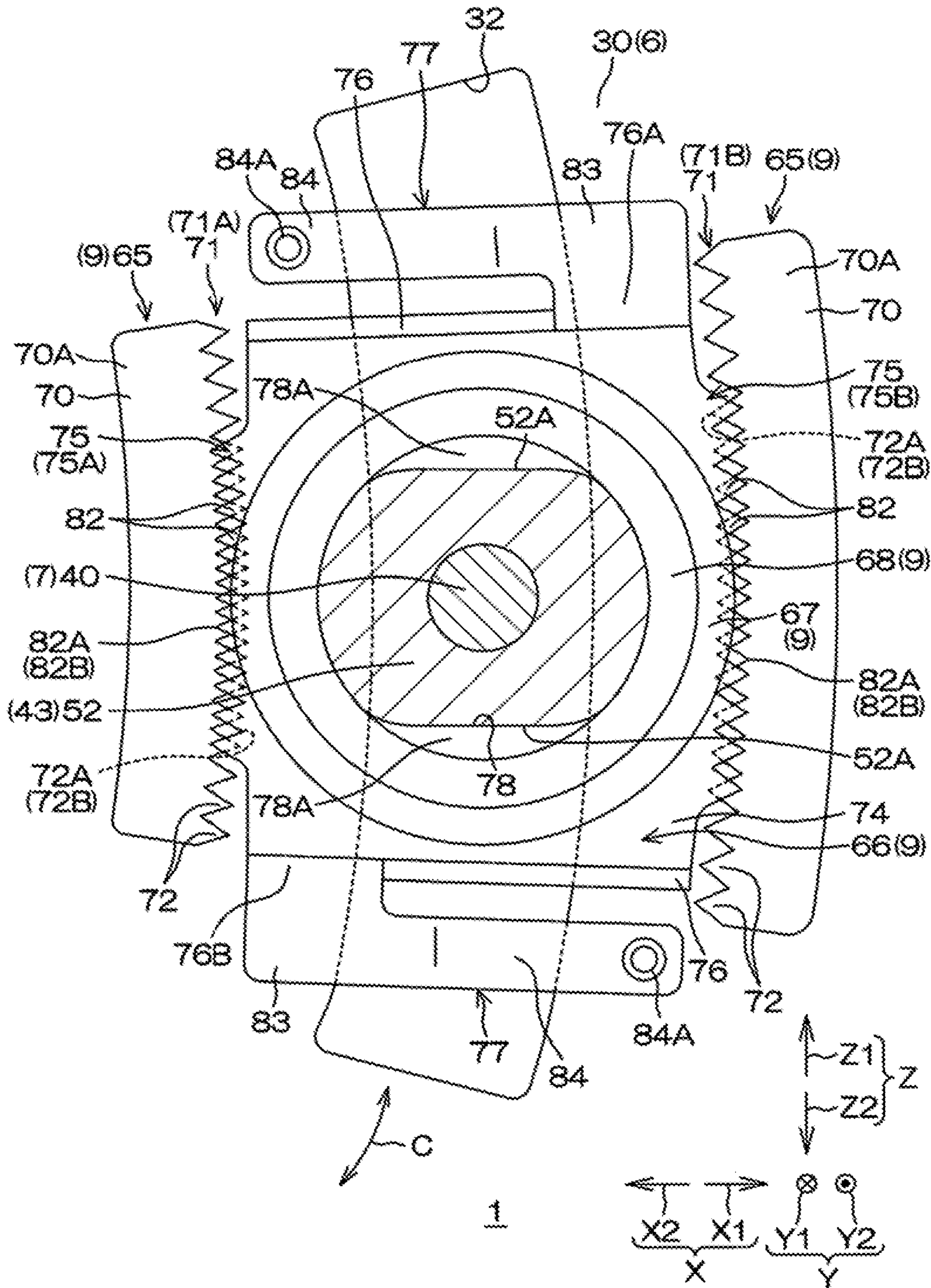


FIG. 9

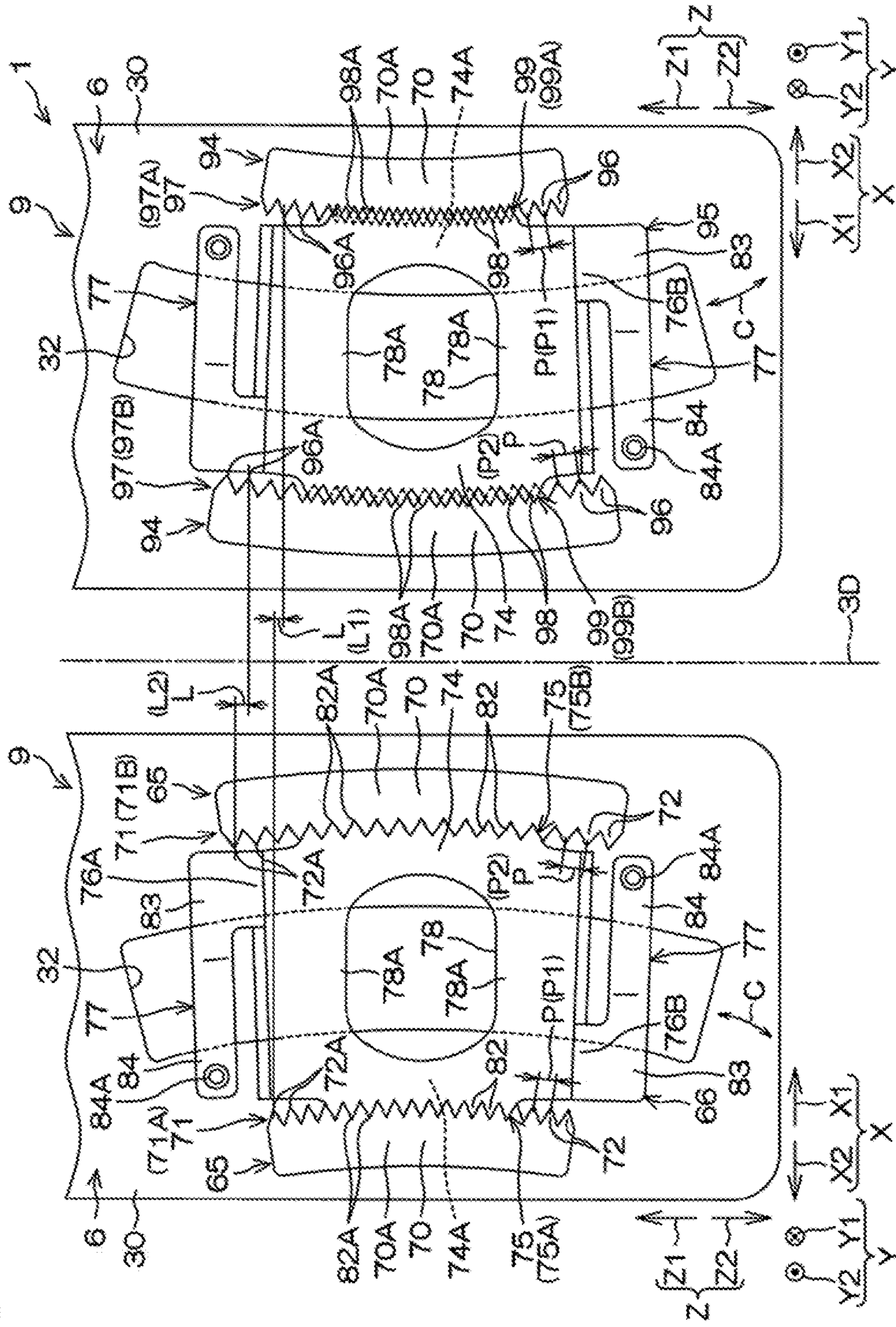


FIG. 10A

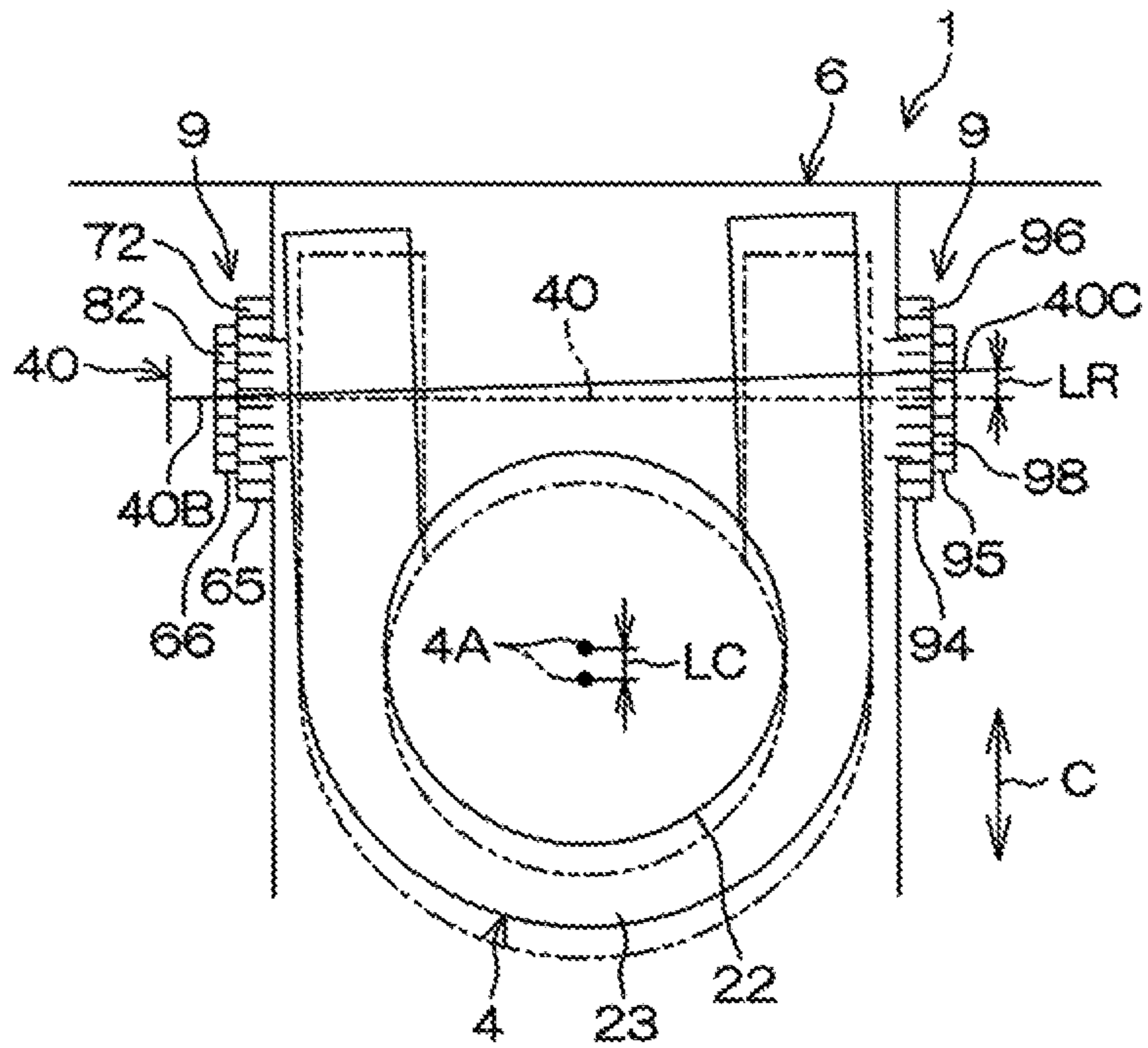


FIG. 10B

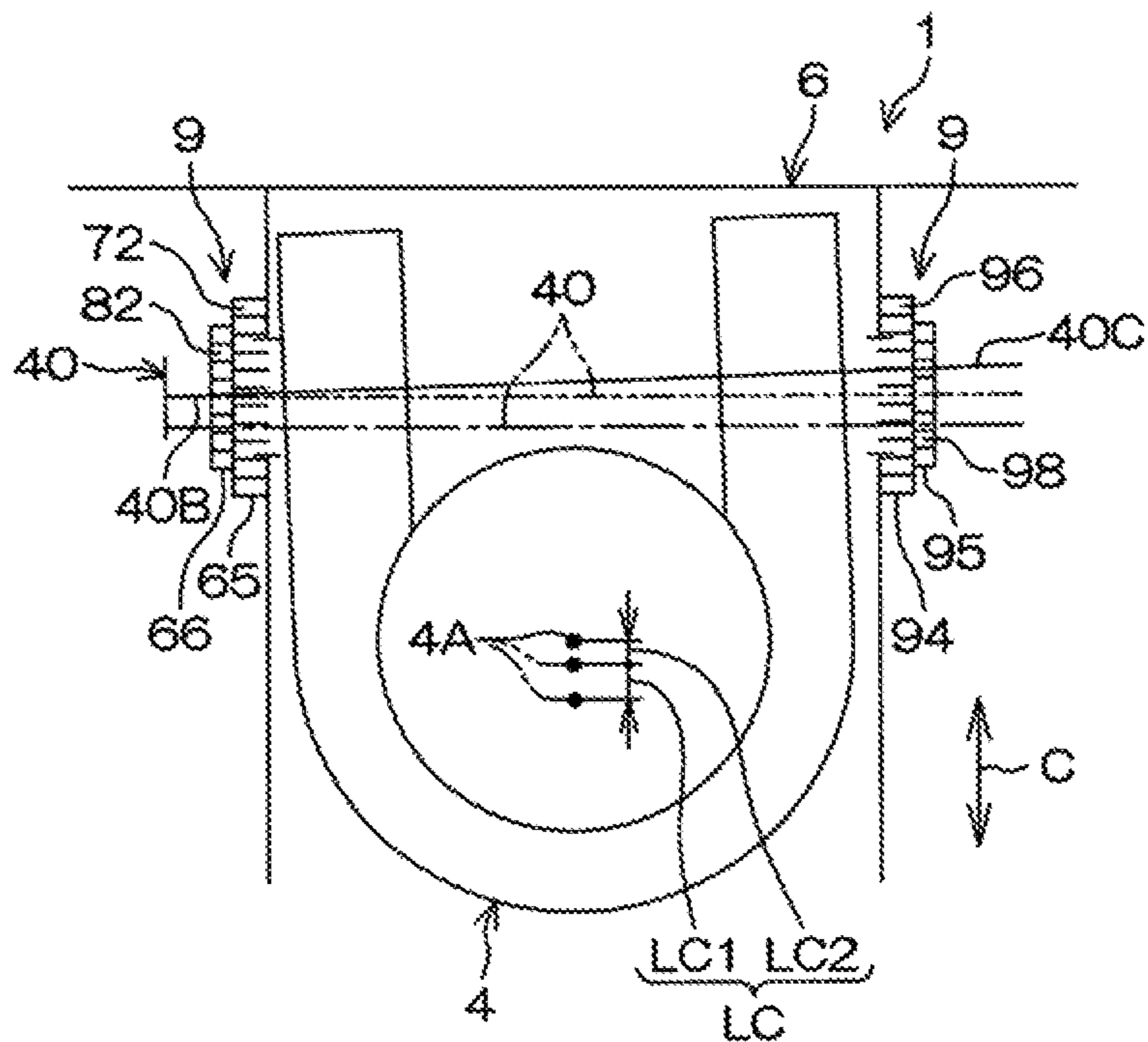


FIG. 11

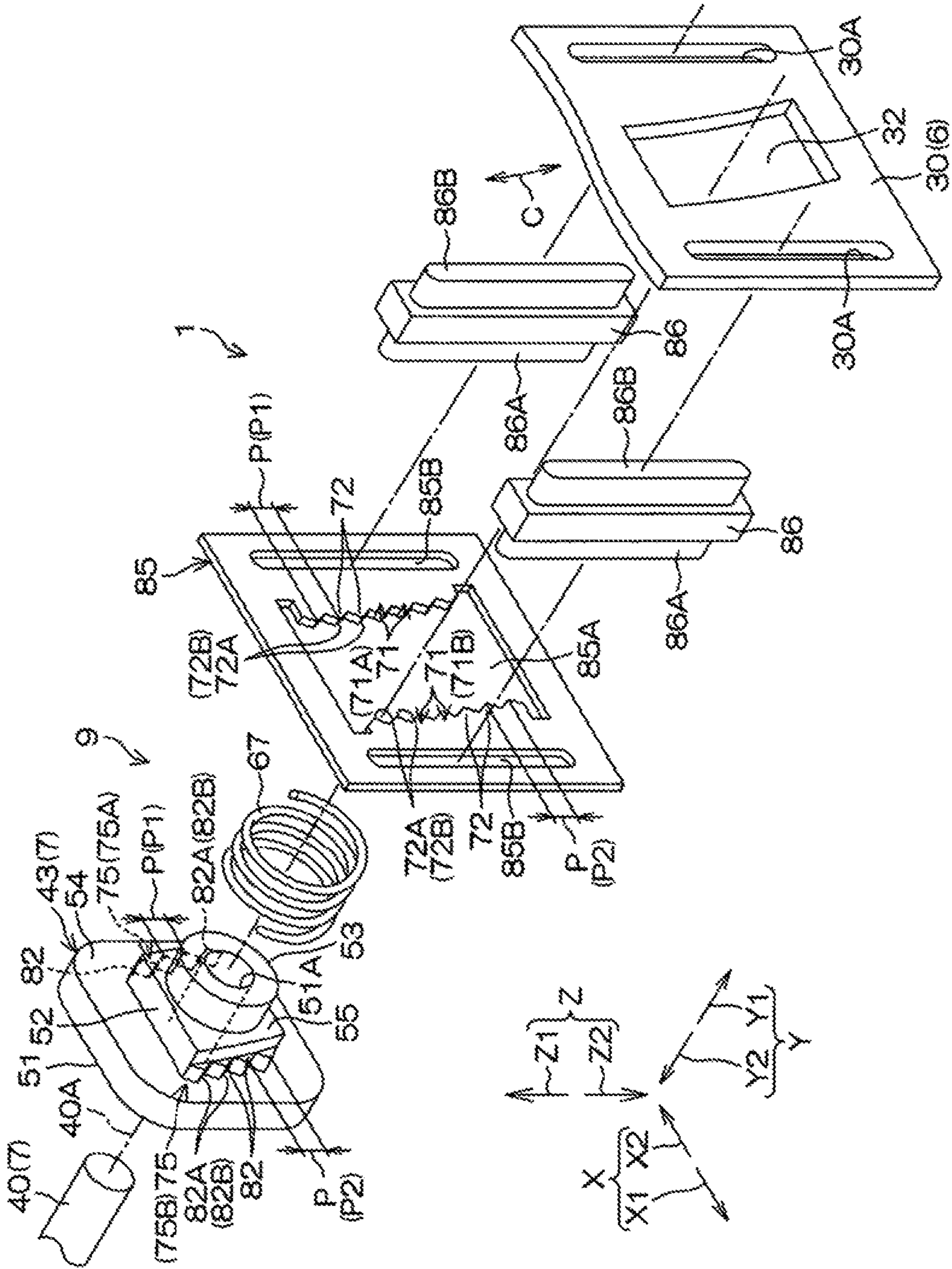
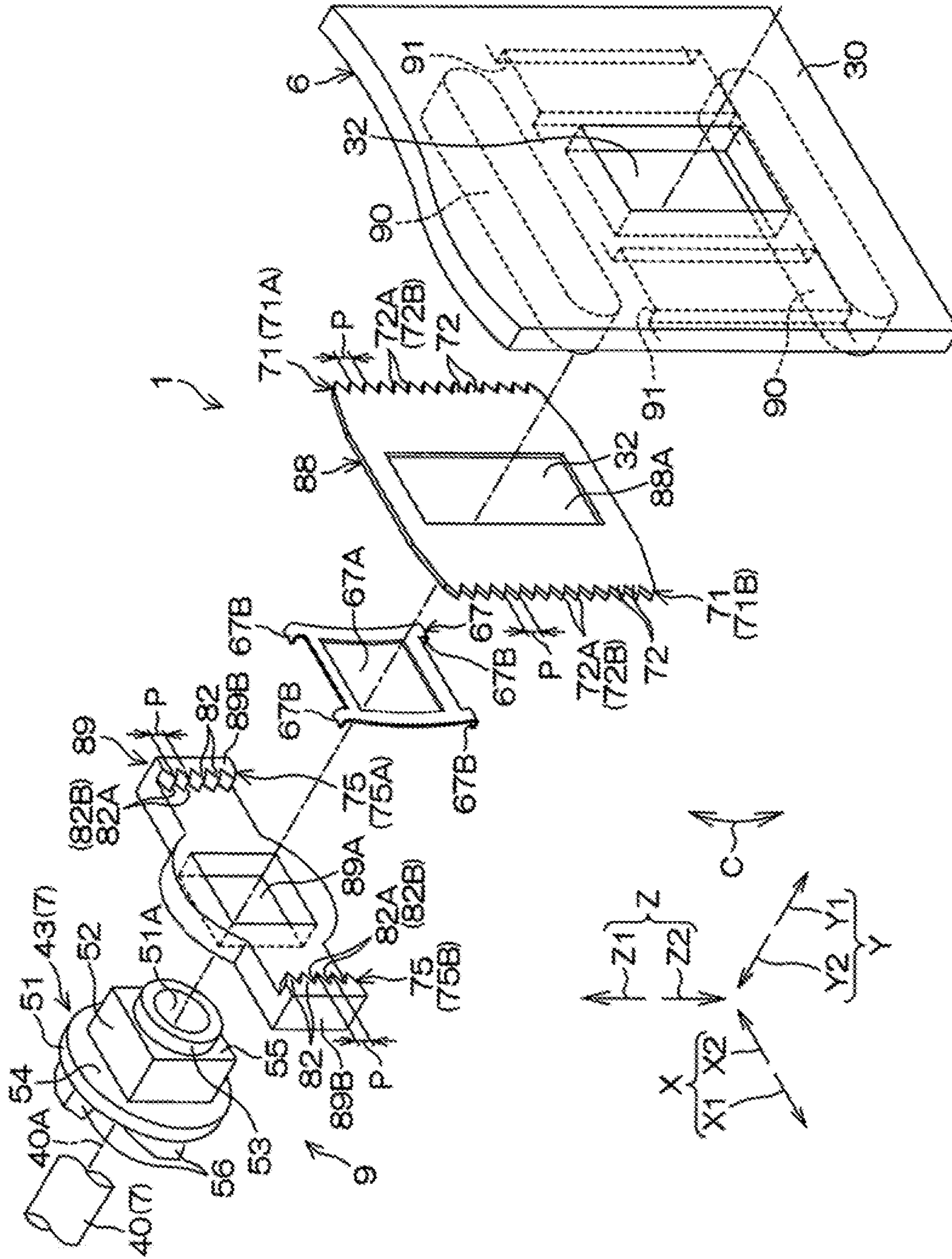


FIG. 13



1

STEERING SYSTEM

INCORPORATION BY REFERENCE

The disclosure of Japanese Patent Application No. 2015-137047 filed on Jul. 8, 2015 including the specification, drawings and abstract, is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a steering system.

2. Description of Related Art

A steering column described in US Patent Application Publication No. 2009/0013817 (US 2009/0013817 A1) includes a setting unit, a holding unit, a tooth plate, a press-on member, and a clamp bolt. The setting unit can be pivoted to adjust the position of the steering column in a certain adjustment direction. The holding unit holds the setting unit. To the setting unit, a jacket unit that holds a steering shaft is attached. The holding unit has a plurality of teeth arranged in the adjustment direction. The tooth plate also has a plurality of teeth arranged in the adjustment direction. The clamp bolt is inserted through the press-on member and the tooth plate, and can be pivoted together with the setting unit.

By operating a lever attached to the clamp bolt, the press-on member can be moved toward the holding unit. When the press-on member moves toward the holding unit, the tooth plate is pressed against the press-on member to move toward the holding unit. When the teeth of the moving tooth plate enter spaces between the teeth of the holding unit, the teeth of the holding unit and the teeth of the tooth plate mesh with each other. Thus, the position of the jacket unit in the adjustment direction is fixed.

By contrast, when the teeth of the tooth plate ride on the teeth of the holding unit without entering the spaces between the teeth of the holding unit, the press-on member bends the tooth plate to press the holding unit. From this state, when the tooth plate moves in the adjustment direction, the tooth plate returns to the previous state in which the tooth plate is not bent, and the teeth of the tooth plate enter the spaces between the teeth of the holding unit. This causes the teeth of the holding unit and the teeth of the tooth plate to mesh with each other, thereby fixing the position of the jacket unit in the adjustment direction.

The adjustment direction defined in US 2009/0013817 A1 is an intersecting direction vertically intersecting the axial direction of the steering shaft. In the steering column of US 2009/0013817 A1, when a vehicle is subjected to strong impact in a collision, for example, with the teeth of the tooth plate riding on the teeth of the holding unit without meshing with the teeth of the holding unit, the jacket unit pivots in the intersecting direction so as to cause the teeth of the holding unit and the teeth of the tooth plate to mesh with each other. In this case, the jacket unit pivots by a length that is substantially equal to the pitch of the teeth at the maximum. In the event of a vehicle collision, in order to stabilize the position of a steering member coupled to the steering shaft, it is desired to reduce the pivoting amount of the jacket unit as small as possible.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a steering system in which the position of a column jacket in a

2

direction intersecting the axial direction of a steering shaft is fixed by causing teeth to mesh with each other and which can reduce the amount of movement of the column jacket in the intersecting direction in a state in which the teeth are riding on each other.

A steering system according to one aspect of the present invention includes: a steering shaft to one end of which a steering member is coupled; a column jacket that holds the steering shaft, has a central axis along an axial direction of the steering shaft, and is movable in an intersecting direction vertically intersecting the axial direction; a bracket that is fixed to a vehicle body, includes a pair of side plates disposed so as to face each other in an orthogonal direction orthogonal to the intersecting direction and the axial direction, and supports the column jacket so that the column jacket is movable between the pair of the side plates; an insertion shaft that extends in the orthogonal direction, that has an end portion at each of outer sides of the pair of the side plates in the orthogonal direction, to which an operation member that is operated to allow and prevent movement of the column jacket with respect to the bracket is attached, and that is movable together with the column jacket in the intersecting direction; a first tooth row that is supported by one of the side plates and includes a plurality of first teeth arranged at a predetermined pitch in the intersecting direction; a second tooth row that is supported by the other of the side plates and includes a plurality of second teeth arranged at the predetermined pitch in the intersecting direction; a third tooth configured to mesh with the first teeth, supported by one end portion of the end portions of the insertion shaft, and configured to come into and out of contact with the first tooth row in accordance with operation of the operation member; and a fourth tooth configured to mesh with the second teeth, supported by the other end portion of the insertion shaft, and configured to come into and out of contact with the second tooth row in accordance with operation of the operation member. In the steering system, either one pair of tooth tips, out of a pair of a tooth tip of each first tooth and a tooth tip of the corresponding second tooth and a pair of a tooth tip of the third tooth and a tooth tip of the corresponding fourth tooth, are located in an identical position in the intersecting direction, and the other pair of tooth tips are displaced from each other by a length that is smaller than the predetermined pitch in the intersecting direction.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and further features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

FIG. 1 is a side view of a schematic structure of a steering system according to one embodiment of the present invention;

FIG. 2 is a perspective view of the steering system;

FIG. 3 is a sectional view along line III-III in FIG. 1;

FIG. 4 is an exploded perspective view of a tilt locking mechanism on the left side;

FIG. 5 is a sectional view along line V-V in FIG. 3;

FIG. 6 is a sectional view along line VI-VI in FIG. 5;

FIG. 7 is a diagram illustrating a released state of the steering system in FIG. 6;

FIG. 8 is a diagram illustrating a state in which second tooth rows are riding on first tooth rows in FIG. 5;

3

FIG. 9 is a schematic diagram for comparing tooth engagement portions and a tooth member on the left side with tooth engagement portions and a tooth member on the right side;

FIG. 10A is a schematic diagram illustrating a state of the steering system after a secondary collision;

FIG. 10B is a schematic diagram illustrating a state of the steering system after a secondary collision occurs in a state different from that in FIG. 10A;

FIG. 11 is an exploded perspective view of a tilt locking mechanism according to a first modification;

FIG. 12 is an exploded perspective view of a tilt locking mechanism according to a second modification; and

FIG. 13 is an exploded perspective view of a tilt locking mechanism according to a third modification.

DETAILED DESCRIPTION OF EMBODIMENTS

Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. FIG. 1 is a side view of a schematic structure of a steering system 1 according to one embodiment of the present invention. In FIG. 1, the left side in the plane of the page corresponds to the front side of a vehicle body 2 on which the steering system 1 is mounted, the right side in the plane of the page corresponds to the rear side of the vehicle body 2, the upper side in the plane of the page corresponds to the upper side of the vehicle body 2, and the lower side in the plane of the page corresponds to the lower side of the vehicle body 2.

As seen in FIG. 1, the steering system 1 mainly includes a steering shaft 3, a column jacket 4, a lower bracket 5, an upper bracket 6, a position adjustment mechanism 7, a telescopic locking mechanism 8 (see FIG. 2 described later), and a tilt locking mechanism 9. To one end 3A that is the rear end of the steering shaft 3, a steering member 11 such as a steering wheel is coupled. In the steering shaft 3, the other end 3B that is the front end thereof is coupled to a pinion shaft 16 of a steering operation mechanism 15 via a universal joint 12, an intermediate shaft 13, and a universal joint 14 in this order.

The steering operation mechanism 15 includes a rack-and-pinion mechanism, for example. The steering operation mechanism 15 turns steered wheels (not depicted) such as tires in accordance with transmitted rotation of the steering shaft 3. The steering shaft 3 extends in the longitudinal direction of the vehicle body 2. Hereinafter, the direction in which the steering shaft 3 extends is called "axial direction X" of the steering shaft 3. The axial direction X is inclined with respect to the horizontal direction so that the other end 3B is positioned lower than the one end 3A. The rear side that is the one end 3A side in the axial direction X is denoted by reference character X1, and the front side that is the opposite side from the one end 3A in the axial direction X is denoted by X2.

Out of orthogonal directions orthogonal to the axial direction X, the direction perpendicular to the plane of the page in FIG. 1 is called "right-and-left direction Y", and the direction extending substantially vertically in FIG. 1 is called "up-and-down direction Z". In the right-and-left direction Y, the side farther from a viewer with respect to the plane of the page of FIG. 1 is the right side Y1, and the side closer to the viewer with respect to the plane of the page is the left side Y2. In the up-and-down direction Z, the upper side is denoted by reference character Z1, and the lower side is denoted by Z2. In the drawings other than FIG. 1, the axial direction, the rear side, the front side, the right-and-left

4

direction, the right side, the left side, the up-and-down direction, the upper side, and the lower side are denoted by the same reference characters as in FIG. 1.

The steering shaft 3 includes an upper shaft 20 and a lower shaft 21 that extend in the axial direction X. The upper shaft 20 is positioned closer to the rear side X1 than the lower shaft 21 is, and is disposed concentrically with the lower shaft 21. A rear end 20A of the upper shaft 20 is the one end 3A of the steering shaft 3. A front end 21A of the lower shaft 21 is the other end 3B of the steering shaft 3. A rear end portion 21B of the lower shaft 21 is inserted into a front end portion 20B from the front side X2. The front end portion 20B is formed in the upper shaft 20 so as to have a cylindrical shape.

The lower shaft 21 is coupled to the upper shaft 20 by spline fitting or serration fitting. Thus, the upper shaft 20 and the lower shaft 21 can rotate together and can move relatively to each other along the axial direction X. By movement of the upper shaft 20 in the axial direction X with respect to the lower shaft 21, the steering shaft 3 can contract and extend along the axial direction X.

The column jacket 4 as a whole is a hollow body extending in the axial direction X. The column jacket 4 accommodates and holds the steering shaft 3. The column jacket 4 includes an upper jacket 22 and a lower jacket 23 each having a tubular shape extending in the axial direction X. The upper jacket 22 is positioned closer to the rear side X1 than the lower jacket 23. The upper jacket 22 part of which is fitted into the lower jacket 23 from the front side X2 can move relatively to the lower jacket 23 in the axial direction X. By this movement of the upper jacket 22 relative to the lower jacket 23, the entire column jacket 4 can extend and contract along the axial direction X. The column jacket 4 supports the steering shaft 3 via a bearing 24 and a bearing 25 so that the steering shaft 3 is rotatable.

The upper shaft 20 and the upper jacket 22 that are coupled to each other can move relatively to the lower shaft 21 and the lower jacket 23 in the axial direction X. Accordingly, the column jacket 4 can contract and extend together with the steering shaft 3. This extension and contraction of the steering shaft 3 and the column jacket 4 is called "telescoping". Adjusting the position of the one end 3A (i.e., the steering member 11 coupled to the one end 3A) of the steering shaft 3 in the axial direction X by the telescoping is called "telescopic adjustment".

The lower bracket 5 includes a pair of right and left movable brackets 5A (see also FIG. 2), a fixed bracket 5B, and a central shaft 5C. The movable brackets 5A are fixed to an upper-side outer peripheral surface of the front end portion 23B of the lower jacket 23. The fixed bracket 5B is fixed to the vehicle body 2. The central shaft 5C extends in the right-and-left direction Y. The central shaft 5C is disposed so as to extend between the movable brackets 5A and passes through the fixed bracket 5B. Thus, the front end portion 23B of the lower jacket 23 is coupled to the vehicle body 2. The movable brackets 5A are formed on the front end portion 23B of the lower jacket 23. Thus, the central shaft 5C is disposed in a position closer to the front side X2 in the column jacket 4.

The movable brackets 5A are supported by the fixed bracket 5B so as to be pivotable about the central shaft 5C. Thus, the entire column jacket 4 together with the steering shaft 3 can pivot about the central shaft 5C up and down with respect to the fixed bracket 5B and the upper bracket 6. This pivoting of the column jacket 4 about the central shaft 5C serving as a pivot axis is called "tilt", and the substantially vertical direction along a circular arc centered on the central

5

shaft 5C is called “tilt direction C”. The tilt direction C is an intersecting direction vertically intersecting the axial direction X, and is orthogonal to the right-and-left direction Y.

Adjusting the position of the steering member 11 in the tilt direction C by the tilt is called “tilt adjustment”. By causing the column jacket 4 to pivot along the tilt direction C, the tilt adjustment can be performed. The lower jacket 23 is coupled to the vehicle body 2 via the lower bracket 5, and thus cannot move in the axial direction X. Accordingly, during the telescopic adjustment, the upper jacket 22 actually moves.

The upper bracket 6 is a bracket that supports the rear end portion 23A of the lower jacket 23 and via which the rear end portion 23A is coupled to the vehicle body 2. As seen in FIG. 2 that is a perspective view of the steering system 1, the upper bracket 6 integrally includes a pair of side plates 30 and a connecting plate 31 that is thin in the up-and-down direction Z. The pair of the side plates 30 are thin in the right-and-left direction Y and face each other with the rear end portion 23A of the lower jacket 23 interposed therebetween. The connecting plate 31 is joined to the respective upper end portions of the pair of the side plates 30.

In the pair of the side plates 30, at the same position when viewed from the right-and-left direction Y, tilt slots 32 are formed. The tilt slots 32 extend in a circular-arc-like manner along the tilt direction C. The connecting plate 31 has portions extending outward of the pair of the side plates 30 in the right-and-left direction Y. The entire upper bracket 6 is fixed to the vehicle body 2 (see FIG. 1) by bolts (not depicted), for example, that are inserted thereinto.

On the upper-side outer peripheral surface of the lower jacket 23, a slit 33 is formed that extends over the entire area in the axial direction X and penetrates the lower jacket 23 in the up-and-down direction Z. On the rear end portion 23A of the lower jacket 23, a pair of extending portions 34 are integrally formed that define the slit 33 from the right-and-left direction Y and extend toward the upper side Z1. Each extending portions 34 has a plate-like shape extending in the axial direction X and the up-and-down direction Z and is thin in the right-and-left direction Y. The pair of the extending portions 34 are disposed between the pair of the side plates 30. Each extending portion 34 faces, from the right-and-left direction Y, the corresponding side plate 30 that is positioned on the same side in the right-and-left direction Y.

FIG. 3 is a sectional view along line III-III in FIG. 1. In FIG. 3, the virtual plane including the central axis 3C of the steering shaft 3 and extending in the up-and-down direction Z is called “reference plane 3D”. The central axis 3C of the steering shaft 3 corresponds to the central axis 4A of the column jacket 4. Thus, the central axis 4A extends along the axial direction X. As seen in FIG. 3, at positions in the pair of the extending portions 34 that are the same when viewed from the right-and-left direction Y, circular insertion holes 35 are formed that penetrate the respective extending portions 34 in the right-and-left direction Y. The insertion holes 35 of the pair of the extending portions 34 overlap part of the tilt slots 32 of the pair of the side plates 30 of the upper bracket 6 when viewed from the right-and-left direction Y.

The position adjustment mechanism 7 is a mechanism configured to release locking of the position of the steering member 11 (see FIG. 1) for tilt adjustment and telescopic adjustment, and to lock the position of the steering member 11 after the tilt adjustment and the telescopic adjustment. The position adjustment mechanism 7 includes a tilt bolt 40 as an insertion shaft, an operation member 41, a cam 42, a moving member 43, a nut 44, a moving member 45, a needle roller bearing 46, and a thrust washer 47.

6

The tilt bolt 40 is a metallic bolt having the central axis 40A extending in the right-and-left direction Y. The tilt bolt 40 has a left end portion 40B as one end portion and a right end portion 40C as the other end portion. In the tilt bolt 40, a head portion 40D is formed on the left end portion 40B, and a thread groove 40E is formed on the outer peripheral surface of the right end portion 40C. A portion of the tilt bolt 40 extending on the right side Y1 of the head portion 40D is inserted into the tilt slots 32 of the pair of the side plates 30 and the insertion holes 35 of the pair of the extending portions 34 in positions closer to the upper side Z1 than the steering shaft 3. In this state, the left end portion 40B and the right end portion 40C are positioned both outside the pair of the side plates 30 in the right-and-left direction Y. Specifically, the left end portion 40B is positioned closer to the left side Y2 than the side plate 30 on the left side Y2, and the right end portion 40C is positioned closer to the right side Y1 than the side plate 30 on the right side Y1.

The operation member 41 is a lever, for example, that can be gripped. In a base end portion 41A of the operation member 41, an insertion hole 41B penetrating the operation member 41 in the right-and-left direction Y is formed. Into the insertion hole 41B, the left end portion 40B of the tilt bolt 40 is inserted, and the base end portion 41A is fixed to the tilt bolt 40. In this manner, to the left end portion 40B of the tilt bolt 40, the operation member 41 is attached. Thus, a user such as a driver can hold a grip 41C of the operation member 41 on the side opposite from the base end portion 41A in the longitudinal direction thereof to operate the operation member 41. The tilt bolt 40 rotates integrally with the operation member 41 about the central axis 40A in accordance with operation of the operation member 41.

The cam 42 integrally includes an annular plate portion 42A and a tubular boss portion 42B. The plate portion 42A is adjacent to the base end portion 41A of the operation member 41 from the right side Y1. The boss portion 42B extends from the plate portion 42A toward the left side Y2. Into a space defined by the respective inner peripheral surfaces of the plate portion 42A and the boss portion 42B, the tilt bolt 40 is inserted. The boss portion 42B is inserted into the insertion hole 41B of the operation member 41. The cam 42 rotates integrally with the tilt bolt 40 and the operation member 41.

FIG. 4 is an exploded perspective view of the tilt locking mechanism 9 on the left side Y2. In FIG. 4, the moving member 43 is a metallic sintered body, for example. The moving member 43 integrally includes a first pressing portion 51, a second pressing portion 52, and a boss portion 53. The first pressing portion 51 is substantially rectangular when viewed from the right-and-left direction Y. In the substantial center of the first pressing portion 51 when viewed from the right-and-left direction Y, a circular through-hole 51A penetrating the first pressing portion 51 in the right-and-left direction Y is formed. The right side surface of the first pressing portion 51 is called “first pressing surface 54”.

The second pressing portion 52 has a block-like shape protruding from the first pressing surface 54 toward the right side Y1, and is substantially circular when viewed from the right side Y1. On both sides of the second pressing portion 52 in the up-and-down direction Z, flat surfaces 52A that are flat along the axial direction X and the right-and-left direction Y are each formed. The right side surface of the second pressing portion 52 is called “second pressing surface 55”. The second pressing surface 55 has a substantially semicircular shape protruding outward in the axial direction X, and a pair of the second pressing surfaces 55 are provided so as

to be separate from each other in the axial direction X. The through-hole 51A of the first pressing portion 51 also penetrates, along the right-and-left direction Y, a portion of the second pressing portion 52 between the pair of the second pressing surfaces 55.

The boss portion 53 has a small piece-like shape protruding from the second pressing portion 52 between the pair of the second pressing surfaces 55 toward the right side Y1, and is substantially rectangular when viewed from the right side Y1. End surfaces 53A of the boss portion 53 on both sides in the axial direction X are flat along the tilt direction C, specifically the tangential direction to the tilt direction C. The flat surface 52A of the second pressing portion 52 on the upper side Z1 is flush with the upper end surface of the boss portion 53. The flat surface 52A of the second pressing portion 52 on the lower side Z2 is flush with the lower end surface of the boss portion 53. Hereinafter, the upper end surface and the lower end surface of the boss portion 53 are considered to be part of the flat surfaces 52A. The through-hole 51A of the first pressing portion 51 also penetrates the boss portion 53 along the right-and-left direction Y. In the right end surface of the boss portion 53, a notch 53B cutting out the boss portion 53 along the axial direction X is formed. The notch 53B is formed on both sides of the through-hole 51A in the axial direction X, and communicates with the through-hole 51A. Thus, the boss portion 53 is divided into upper and lower parts by the through-hole 51A and the notches 53B.

As seen in FIG. 3, into the through-hole 51A of the moving member 43, the left end portion 40B of the tilt bolt 40 is inserted with a small clearance. Thus, the moving member 43 is supported by the left end portion 40B of the tilt bolt 40. The first pressing portion 51 of the moving member 43 is adjacent to the plate portion 42A of the cam 42 from the right side Y1. On the right side surface of the plate portion 42A and the left side surface of the first pressing portion 51, cam protrusions 56 are formed.

The boss portion 53 of the moving member 43 is inserted into the tilt slot 32 of the side plate 30 on the left side Y2. The respective end surfaces 53A of the boss portion 53 on both sides in the axial direction X lie along a pair of edge portions 32A extending parallel to each other along the tilt direction C in the tilt slot 32 (see FIG. 4). This prevents idle rotation of the moving member 43 in the tilt slot 32 and corotation of the moving member 43 with the tilt bolt 40.

The pair of the second pressing surfaces 55 of the second pressing portion 52 of the moving member 43 are in contact with, from the left side Y2, peripheral portions of the tilt slot 32 at the left side surface of the side plate 30 on the left side Y2. To the thread groove 40E of the tilt bolt 40, the nut 44 is attached. Between the nut 44 and the side plate 30 on the right side Y1, the moving member 45, the annular needle roller bearing 46, and the thrust washer 47 are arranged in this order from the left side Y2.

The shape of the moving member 45 is substantially the same as the shape of the moving member 43, as the moving member 43 is flipped to the right side Y1 with respect to the reference plane 3D. However, unlike the moving member 43, the moving member 45 does not have the cam protrusion 56. Portions of the moving member 45 that correspond to the respective portions of the moving member 43 are denoted by the same reference characters, and detailed description of those portions is omitted. The right end portion 40C of the tilt bolt 40 is inserted into each of the moving member 45, the needle roller bearing 46, and the thrust washer 47. Into the through-hole 51A of the moving member 45, the right end portion 40C of the tilt bolt 40 is inserted with a small

clearance. The boss portion 53 of the moving member 45 is inserted into the tilt slot 32 on the right side Y1. In the same manner as in the moving member 43, idle rotation of the moving member 45 in the tilt slot 32 and corotation of the moving member 45 with the tilt bolt 40 are prevented. The second pressing surfaces 55 of the second pressing portion 52 of the moving member 45 are in contact with, from the right side Y1, peripheral portions of the tilt slot 32 at the right side surface of the side plate 30 on the right side Y1.

In the tilt slots 32 of the right and left side plates 30 in the upper bracket 6, the tilt bolt 40 can move in the tilt direction C along the tilt slots 32 together with the respective boss portions 53 of the moving members 43 and 45. In the insertion holes 35 of the lower jacket 23 of the column jacket 4, the tilt bolt 40 can rotate about the central axis 40A but cannot move in the other directions. Thus, when the column jacket 4 is tilted for tilt adjustment, the tilt bolt 40 pivots in the tilt direction C together with the column jacket 4. In this manner, the upper bracket 6 supports the column jacket 4 via the tilt bolt 40 so that the column jacket 4 is pivotable. Tilt adjustment is performed within a movable range of the boss portions 53 in the tilt slots 32.

When the user operates and rotates the operation member 41 after telescopic adjustment and/or tilt adjustment, the cam 42 rotates, and the cam protrusions 56 of the cam 42 and the moving member 43 ride on each other. This causes the moving member 43 to move toward the right side Y1 along the tilt bolt 40 extending in the right-and-left direction Y, thereby pressing the second pressing surface 55 against the left side surface of the side plate 30 on the left side Y2 from the left side Y2. Accordingly, the moving member 45 is pulled along the tilt bolt 40 toward the left side Y2, and the second pressing surfaces 55 of the moving member 45 press the right side surface of the side plate 30 on the right side Y1 from the right side Y1. Thus, the distance between the moving member 43 and the moving member 45 in the right-and-left direction Y is narrowed, whereby the pair of the side plates 30 are clamped between the moving member 43 and the moving member 45 from both sides in the right-and-left direction Y. In this state, each extending portion 34 is frictionally held by the corresponding side plate 30, and the upper jacket 22 is frictionally held by the lower jacket 23 that is reduced in diameter by the clamping. This prevents rotation and extension/contraction of the column jacket 4, thereby preventing the steering member 11 (see FIG. 1) from moving in the tilt direction C and the axial direction X.

The state of the steering system 1 in which the position of the steering member 11 is locked in the tilt direction C and the axial direction X in this manner is called "locked state". The respective positions of the moving member 43 and the moving member 45 in the right-and-left direction Y in the locked state are called "locked positions". During normal driving, the steering system 1 is in the locked state. In the steering system 1 in the locked state, when the operation member 41 is operated to be rotated toward the direction opposite to that described above, the cam 42 rotates relatively to the moving member 43. This releases the riding of the cam protrusions 56 of the cam 42 and the moving member 43 on each other. Accordingly, the moving member 43 moves along the tilt bolt 40 from the locked position toward the left side Y2. In conjunction with this movement of the moving member 43, the moving member 45 moves along the tilt bolt 40 toward the right side Y1. This widens the distance between the moving member 43 and the moving member 45, thereby releasing the clamping of the pair of the side plates 30 between the moving member 43 and the

moving member 45. In this state, the frictional holding between each side plate 30 and the corresponding extending portion 34 and the frictional holding between the lower jacket 23 and the upper jacket 22 are released. This allows rotation and extension/contraction of the column jacket 4, so that the steering member 11 can move in the tilt direction C and the axial direction X. Telescopic adjustment and tilt adjustment are thus enabled again.

The state of the steering system 1 in which the fixing of the position of the steering member 11 is released in the tilt direction C and the axial direction X is called “released state”. The respective positions of the moving member 43 and the moving member 45 in the right-and-left direction Y in the released state are called “released positions”. The telescopic locking mechanism 8 includes a tubular locking member 57, a transmission member 58, and a locking plate 59. The telescopic locking mechanism 8 firmly locks the position of the upper jacket 22 in the axial direction X by intermeshing between teeth 60 on the outer peripheral surface of the locking member 57 and teeth 61 of the locking plate 59, and releases this intermeshing to release the locking of the upper jacket 22. In the steering system 1 in the locked state, the position adjustment mechanism 7 locks the position of the upper jacket 22 in the axial direction X with frictional force. Intermeshing between the teeth 60 and the teeth 61 further enhances this locking.

The tilt locking mechanism 9 is a mechanism configured to, in the steering system 1 in the locked state, firmly lock the position of the column jacket 4 in the tilt direction C and release this locking. The tilt locking mechanism 9 is provided near each of the pair of the side plates 30. As seen in FIG. 4, the tilt locking mechanism 9 on the left side Y2 includes the moving member 43, a tooth engagement portion 65, a tooth member 66, an elastic member 67, and a spacer 68. The tooth engagement portion 65 is provided to the side plate 30 on the left side Y2.

The tooth engagement portion 65 is formed integrally with the side plate 30 on the left side Y2 by extrusion molding, for example, to be supported by the side plate 30 on the left side Y2, and protrudes from the left side surface of the side plate 30 on the left side Y2 toward the left side Y2. Thus, in FIG. 4, the tooth engagement portion 65 is positioned behind the side plate 30 on the left side Y2. On the right side surface of the side plate 30 on the left side Y2, as a mark of extrusion molding, a depression 65A the size of which is substantially the same as that of the tooth engagement portion 65 is formed. The tooth engagement portion 65 is formed in a pair so as to sandwich the tilt slot 32 from both sides in the axial direction X. The tooth engagement portions 65 each integrally have a holding portion 70 and a first tooth row 71. The holding portion 70 extends in a belt-like shape along the tilt direction C. The first tooth row 71 protrudes from the holding portion 70 toward the tilt slot 32. Because the pair of the tooth engagement portions 65 are arranged side by side in the axial direction X, the first tooth row 71 is formed in a pair arranged side by side in the axial direction X. The pair of the first tooth rows 71 include one first tooth row 71A and the other first tooth row 71B. The one first tooth row 71A is positioned on the front side X2 of the tilt slot 32. The other first tooth row 71B is positioned on the rear side X1 of the tilt slot 32. The first tooth row 71A is positioned closer to the central shaft 5C (see FIG. 1) of the lower bracket 5 that is a pivot axis of the column jacket 4, and the first tooth row 71B is positioned more distant from the central shaft 5C than the first tooth row 71A.

FIG. 5 is a sectional view along line V-V in FIG. 3. As seen in FIG. 5, the left end surfaces of the holding portions

70 are engaged surfaces 70A that are flat in the axial direction X and the tilt direction C. Each first tooth row 71 includes a plurality of first teeth 72 that are arranged at regular intervals along the circular-arc-like tilt direction C. Specifically, the first teeth 72 of the first tooth row 71A on the front side X2 are arranged at a predetermined pitch P1. The first teeth 72 of the first tooth row 71B on the rear side X1 are arranged at a predetermined pitch P2. Hereinafter, the pitch P1 and the pitch P2 are also collectively called “pitch P”.

Each first tooth 72 is substantially triangular when viewed from the left side Y2, and has a tooth tip 72A that is directed to the tilt slot 32 side. Specifically, the tooth tip 72A of each first tooth 72 in the first tooth row 71A on the front side X2 is directed to the rear side X1 to face the tilt slot 32. The tooth tip 72A of each first tooth 72 in the first tooth row 71B on the rear side X1 is directed to the front side X2 to face the tilt slot 32. In each first tooth 72, a tooth trace 72B formed by the corresponding tooth tip 72A extends in the right-and-left direction Y (see also FIG. 6 described later). The left end surfaces of the first teeth 72 are each flush with the engaged surface 70A of the holding portion 70.

As seen in FIG. 4, each tooth member 66 is formed by processing one metal plate by press molding, for example. The tooth member 66 integrally includes a body portion 74, a pair of third tooth rows 75, a pair of ribs 76, and a pair of spring portions 77. The body portion 74 has a plate-like shape that is thin in the right-and-left direction Y, and has a substantially rectangular shape long in the tilt direction C. The right side surface of the body portion 74 is an engaging surface 74A that is flat in the axial direction X and the tilt direction C.

In the substantial center of the body portion 74 in the axial direction X and the up-and-down direction Z, a through-hole 78 penetrating the body portion 74 in the right-and-left direction Y is formed. When viewed from the right-and-left direction Y, the through-hole 78 has a substantially circular shape having substantially the same size as that of the second pressing portion 52 of the moving member 43. Thus, in the body portion 74, peripheral portions 78A define both ends of the through-hole 78 in the up-and-down direction Z. The peripheral portions 78A extend parallel to the flat surfaces 52A of the second pressing portion 52.

The third tooth rows 75 are each formed on both end edges of the body portion 74 in the axial direction X. Each third tooth row 75 includes a plurality of third teeth 82 that are arranged at regular intervals along the tilt direction C. Specifically, the third teeth 82 of the third tooth row 75A on the front side X2 that is formed on the front end edge of the body portion 74, out of the pair of the third tooth rows 75, are arranged at the predetermined pitch P1, and the third teeth 82 of the third tooth row 75B on the rear side X1 that is formed on the rear end edge of the body portion 74 are arranged at the predetermined pitch P2 (see FIG. 5). Each third tooth 82 is substantially triangular when viewed from the right-and-left direction Y, and has a tooth tip 82A that is directed outward of the body portion 74 in the axial direction X. Specifically, the tooth tip 82A of each third tooth 82 in the third tooth row 75A on the front side X2 is directed to the front side X2. The tooth tip 82A of each third tooth 82 in the third tooth row 75B on the rear side X1 is directed to the rear side X1. In each third tooth 82, a tooth trace 82B formed by the corresponding tooth tip 82A extends in the right-and-left direction Y (see also FIG. 6 described later). The left end surface of each third tooth 82 is part of the left side surface

11

of the body portion 74, and the right end surface of each third tooth 82 is part of the engaging surface 74A of the body portion 74.

The pair of the ribs 76 are formed by bending both end portions of the body portion 74 in the up-and-down direction Z toward the left side Y2. Accordingly, each rib 76 is thin in the up-and-down direction Z, and extends long and narrow along the axial direction X. The pair of the spring portions 77 each have a support portion 83 and a deformation portion 84. The support portion 83 protrudes from each rib 76 so as to be separated from the body portion 74 in the up-and-down direction Z. The deformation portion 84 is supported by the support portion 83 and can elastically deform in the right-and-left direction Y. The support portion 83 of the spring portion 77 on the upper side Z1, out of the pair of the spring portions 77, extends from a rear end portion 76A of the rib 76 on the upper side Z1 toward the upper side Z1. The support portion 83 of the spring portion 77 on the lower side Z2 extends from a front end portion 76B of the rib 76 on the lower side Z2 toward the lower side Z2. Each support portion 83 is a plate-like shape that is thin in the right-and-left direction Y. The deformation portion 84 of the spring portion 77 on the upper side Z1 extends from the front end portion of the support portion 83 on the upper side Z1 obliquely toward the front side X2 and the right side Y1. The deformation portion 84 of the spring portion 77 on the lower side Z2 extends from the rear end portion of the support portion 83 on the lower side Z2 obliquely toward the rear side X1 and the right side Y1. On a distal end portion of each deformation portion 84, a contact portion 84A is formed having a projecting shape that is pressed out toward the right side Y1.

The tooth member 66 is disposed between the first pressing portion 51 of the moving member 43 and the side plate 30 on the left side Y2. As seen in FIG. 6 that is a sectional view along line VI-VI in FIG. 5, into the through-hole 78 of the body portion 74 of the tooth member 66, the second pressing portion 52 of the moving member 43 is inserted. Thus, the tooth member 66 is supported by the left end portion 40B of the tilt bolt 40 via the moving member 43. In this state, the tooth member 66 can move relatively to the second pressing portion 52 in the right-and-left direction Y. However, because the through-hole 78 has substantially the same size as that of the second pressing portion 52 as described above, rotation of the tooth member 66 relative to the moving member 43 is restricted.

The engaging surface 74A of the body portion 74 in the tooth member 66 faces an area between the pair of the first tooth rows 71 in the left side surface of the side plate 30 on the left side Y2 (see also FIG. 4). The contact portions 84A of the spring portions 77 of the tooth member 66 are in contact with the left side surface of the side plate 30 on the left side Y2 from the left side Y2 (see FIG. 5). The elastic member 67 is a coned disc spring, for example. In FIG. 6, the elastic member 67 has a substantially annular shape that widens in the radial direction of the tilt bolt 40 toward the right side Y1. Alternatively, the elastic member 67 may have a substantially annular shape that widens in the radial direction toward the left side Y2.

Into the hollow portion of the elastic member 67, the second pressing portion 52 of the moving member 43 is inserted. The elastic member 67 is disposed between the tooth member 66 and the first pressing portion 51 of the moving member 43. The inner peripheral edge of the left end portion of the elastic member 67 lies along portions in the outer peripheral surface of the second pressing portion 52 other than the flat surfaces 52A (see FIG. 4). The right end

12

portion of the elastic member 67 is in contact with the left side surface of the body portion 74 of the tooth member 66 and part of the third tooth rows 75 (see FIG. 5).

The spacer 68 is a metallic sintered body, for example, having an annular shape that is thin in the right-and-left direction Y (see FIG. 4). The spacer 68 is fit onto the second pressing portion 52 of the moving member 43 from the right side Y1. The inner peripheral surface of the spacer 68 lies along portions in the outer peripheral surface of the second pressing portion 52 other than the flat surfaces 52A (see FIG. 5). The spacer 68 is disposed between the first pressing portion 51 of the moving member 43 and the elastic member 67. The left side surface of the spacer 68 is in surface contact with the first pressing surface 54 of the first pressing portion 51 from the right side Y1. The entire area of the right side surface of the spacer 68 in the circumferential direction is in contact with the left end portion of the elastic member 67 from the left side Y2.

As described above, the tilt bolt 40 that can pivot together with the column jacket 4 in the tilt direction C is inserted into the through-hole 51A of the moving member 43. The second pressing portion 52 of the moving member 43 is inserted into the tooth member 66, the elastic member 67, and the spacer 68. Thus, during tilt adjustment, the tooth member 66, the elastic member 67, and the spacer 68 pivot together with the column jacket 4 in the tilt direction C.

The following describes operation of the tilt locking mechanism 9 on the left side Y2 when the steering system 1 is changed into the locked state. In FIG. 5 and FIG. 6, the steering system 1 in the locked state is illustrated. In the following description, unless otherwise mentioned, it is assumed that, in a stage before the steering system 1 is changed into the locked state, the first teeth 72 of the first tooth rows 71 and the third teeth 82 of the third tooth rows 75 are positioned so that the phases thereof match each other and thus these teeth do not overlap each other when viewed from the right-and-left direction Y.

When the operation member 41 (see FIG. 3) is operated to change the steering system 1 into the locked state, the moving member 43 moves toward right side Y1 from the released position to the locked position. The tooth member 66 is caused to move toward the right side Y1 by the first pressing portion 51 of the moving member 43 via the spacer 68 and the elastic member 67. Consequently, when the steering system 1 has been changed into the locked state, as depicted in FIG. 5 and FIG. 6, the tooth member 66 reaches the area between the pair of the first tooth rows 71 on the left side surface of the side plate 30 on the left side Y2 in the upper bracket 6. Thus, the third tooth rows 75 of the tooth member 66 become close to the first tooth rows 71, and the engaging surface 74A of the body portion 74 of the tooth member 66 (see FIG. 6) comes into surface contact with the left side surface of the side plate 30 on the left side Y2. In this state, the first teeth 72 of the first tooth row 71A on the front side X2 in the side plate 30 and the third teeth 82 of the third tooth row 75A on the front side X2 in the tooth member 66 mesh with each other alternately arranged in the tilt direction C. The first teeth 72 of the first tooth row 71B on the rear side X1 and the third teeth 82 of the third tooth row 75B on the rear side X1 mesh with each other alternately arranged in the tilt direction C.

Thus, the pair of the first tooth rows 71 and the pair of the third tooth rows 75 intermesh with each other. Accordingly, in this state, the column jacket 4 that moves integrally with the tilt bolt 40 supporting the tooth member 66 cannot pivot, so that the position of the column jacket 4 in the tilt direction C is fixed. Thus, in the locked state, by frictional holding

between each extending portion 34 of the lower jacket 23 and the corresponding side plate 30 of the upper bracket 6, and intermeshing between the first tooth rows 71 and the third tooth rows 75, the position of the upper jacket 22 in the tilt direction C is more firmly locked.

In the locked state, the deformation portions 84 of the spring portions 77 of the tooth member 66 are pressed against the side plates 30 to elastically deform in the right-and-left direction Y. Accordingly, by restoring force of the deformation portions 84 returning to their original state, the entire tooth member 66 is biased toward the elastic member 67 on the left side Y2 as depicted in FIG. 6. The elastic member 67 is sandwiched by the tooth member 66 and the first pressing portion 51 of the moving member 43 to be compressed in the right-and-left direction Y, whereby the restoring force returning to the original state is generated.

It is assumed in FIG. 1 that, in the event of a vehicle collision, after a primary collision in which a vehicle collides with an obstacle, a secondary collision occurs in which a driver collides with the steering member 11. In the secondary collision, by reaction force that is generated by deployment of an airbag mounted in the steering member 11 and collision of the driver with the airbag, the steering member 11 receives an impact in the axial direction X and the tilt direction C. In the tilt direction C in particular, the steering member 11 attempts to move upward together with the column jacket 4. However, in the steering system 1, the position of the column jacket 4 in the axial direction X and the tilt direction C is maintained by the position adjustment mechanism 7 and, in addition, the positions of the column jacket 4 and the steering member 11 in the tilt direction C are firmly maintained by the tilt locking mechanism 9. Thus, in the secondary collision, free movement of the column jacket 4 in an initial stage in particular can be suppressed, and the position of the airbag in the tilt direction C can be maintained properly. When the steering member 11 moves toward the front side X2 so as to absorb the impact in the secondary collision, the steering member 11 can be caused to move forward in a stable attitude. This can stabilize detachability in the secondary collision. Maintaining the position of the column jacket 4 by the tilt locking mechanism 9 as described above is called "positive locking".

The following describes operation of the tilt locking mechanism 9 on the left side Y2 when the steering system 1 is changed from the locked state into the released state. The following refers to also FIG. 7 illustrating the released state of the steering system 1 in FIG. 6. When the operation member 41 is operated to change the steering system 1 into the released state, the moving member 43 moves from the locked position toward the left side Y2. When the moving member 43 moves toward the left side Y2, the distance between the tooth member 66 and the first pressing portion 51 of the moving member 43 increases, and accordingly the compressed amount of the elastic member 67 in the right-and-left direction Y gradually decreases. When the steering system 1 has been changed into the released state as depicted in FIG. 7, the elastic member 67 becomes uncompressed.

As described above, when the steering system 1 is in the locked state, the deformation portions 84 of the spring portions 77 of the tooth member 66 elastically deform. Accordingly, the entire tooth member 66 is biased toward the left side Y2 by the restoring force of the deformation portions 84. When the moving member 43 is moved toward the left side Y2 and the elastic member 67 accordingly becomes uncompressed to change the steering system 1 into the released state, the tooth member 66 moves toward the

left side Y2 by the restoring force of the deformation portions 84. Accordingly, the third tooth rows 75 of the tooth member 66 move toward the left side Y2. Thus, the steering system 1 is changed into the released state. The third tooth rows 75 have moved to be positioned more toward the left side Y2 than the first tooth rows 71, and thus the intermeshing between the third tooth rows 75 and the first tooth rows 71 is released. At this time, the moving member 43 is positioned in the released position.

As described above, the third tooth rows 75 can come into and out of contact with the first tooth rows 71 in accordance with operation of the operation member 41 (see FIG. 3). As described above, in the released state, the frictional force between the side plates 30 of the upper bracket 6 and the extending portions 34 of the lower jacket 23 disappears. Thus, in the released state, locking of the position of the column jacket 4 in the tilt direction C is completely released. This allows tilt adjustment of the steering member 11.

FIG. 8 is a diagram illustrating a state in which the third tooth rows 75 are riding on the first tooth rows 71 in FIG. 5. The following assumes a case in which the user operates the operation member 41 so as to change the steering system 1 into the locked state, with the third tooth rows 75 riding on the first tooth rows 71. In the state in which the third tooth rows 75 are riding on the first tooth rows 71, as depicted in FIG. 8, the first teeth 72 and the third teeth 82 overlap each other when viewed from the right-and-left direction Y due to the unmatched phases. Thus, so-called a tooth-on-tooth position occurs, in which the first tooth rows 71 and the third tooth rows 75 do not mesh with each other and the third tooth rows 75 ride on the first tooth rows 71. The state of the steering system 1 in which the tooth-on-tooth position occurs is called "tooth-on-tooth state".

In the tooth-on-tooth state, in the same manner as in the locked state, the position of the column jacket 4 is locked by the position adjustment mechanism 7 (see FIG. 1). The steering member 11 is locked at the position where tilt adjustment has been completed. Thus, regardless of the positional relationship between the first tooth rows 71 and the third tooth rows 75, tilt adjustment can be performed steplessly in any position where the tilt position is adjusted. In the tooth-on-tooth state, the position of the column jacket 4 in the tilt direction C is locked mainly by the frictional force between the side plate 30 and the extending portion 34. Thus, when impact caused by a secondary collision, for example, exceeds the frictional force, slippage occurs between the first tooth rows 71 and the third tooth rows 75, and the column jacket 4 tends to pivot in the tilt direction C. In this case, when the column jacket 4 pivots in the tilt direction C by a length equal to or smaller than the pitch P of the first teeth 72 and the third teeth 82, the first teeth 72 of the first tooth rows 71 and the third teeth 82 of the third tooth rows 75 are alternately arranged in the tilt direction C. This prevents the third tooth rows 75 from riding on the first tooth rows 71. The tooth member 66 having the third tooth rows 75 receives the restoring force of the elastic member 67 that is compressed in the right-and-left direction Y. Thus, the tooth member 66 moves toward the side plate 30 of the upper bracket 6, and the first tooth rows 71 and the third tooth rows 75 mesh with each other. Thus, the steering system 1 is changed from the tooth-on-tooth state into the locked state. Consequently, by the positive locking, pivoting of the column jacket 4 in the tilt direction C can be prevented. The length by which the third teeth 82 move in the tilt direction C before meshing with the first tooth rows 71 when a secondary collision occurs in the tooth-on-tooth state is called "free-moving length".

By the combination of the elastic member 67 using a coned disc spring and the spacer 68, the restoring force can be kept substantially constant. This enables the user to operate the operation member 41 smoothly without feeling heaviness during the entire operation even with the third tooth rows 75 riding on the first tooth rows 71. Needless to say, the elastic member 67 and the spacer 68 may be omitted as necessary.

As seen in FIG. 3, the tilt locking mechanism 9 on the right side Y1 includes the moving member 45, tooth engagement portions 94 (see FIG. 9 described later), and a tooth member 95 instead of the moving member 43, the tooth engagement portions 65 (see FIG. 4), and the tooth member 66, respectively, of the tilt locking mechanism 9 on the left side Y2. The tilt locking mechanism 9 on the right side Y1 includes the elastic member 67 and the spacer 68 in the same manner as the tilt locking mechanism 9 on the left side Y2.

Each of the moving member 45, the elastic member 67, and the spacer 68 of the tilt locking mechanism 9 on the right side Y1 and each of the moving member 43, the elastic member 67, and the spacer 68 of the tilt locking mechanism 9 on the left side Y2 are disposed symmetrically with respect to the reference plane 3D. FIG. 9 is a schematic diagram for comparing the tooth engagement portions 65 and the tooth member 66 on the left side Y2 with the tooth engagement portions 94 and the tooth member 95 on the right side Y1. In FIG. 9, the tooth engagement portions 65 and the tooth member 66 on the left side Y2 are different in orientation from the tooth engagement portions 94 and the tooth member 95 on the right side Y1. Accordingly, for each of the tilt locking mechanisms 9 on the right side Y1 and on the left side Y2, the respective directions are indicated.

As seen in FIG. 9, the shapes of the tooth engagement portions 94 and the tooth member 95 of the tilt locking mechanism 9 on the right side Y1 are substantially the same as the shapes of the tooth engagement portions 65 and the tooth member 66 of the tilt locking mechanism 9 on the left side Y2 that are flipped to the right side Y1 with respect to the reference plane 3D, respectively. Portions of the tooth engagement portions 94 and the tooth member 95 that correspond to the respective portions of the tooth engagement portions 65 and the tooth member 66 are denoted by the same reference characters, and detailed description of these portions is omitted. The operation of the tilt locking mechanism 9 on the right side Y1 is almost the same as the operation of the tilt locking mechanism 9 on the left side Y2 except that the right-and-left orientation is reversed.

The tooth engagement portions 94 are different from the tooth engagement portions 65 in having, instead of the first tooth rows 71 of the tooth engagement portions 65, second tooth rows 97 each including a plurality of second teeth 96 that are arranged in the tilt direction C. The shapes of the second teeth 96 are the same as the shapes of the first teeth 72 of the tooth engagement portions 65 that are flipped to the right side Y1 with respect to the reference plane 3D. However, the position of a tooth tip 96A of each second tooth 96 in the tilt direction C and the position of the tooth tip 72A of the corresponding first tooth 72 in the tilt direction C are not the same, and are displaced from each other. Specifically, the tooth tip 96A of each second tooth 96 of the second tooth row 97A on the front side X2 is located in a position that is displaced in the tilt direction C from a position of the tooth tip 72A of the corresponding first tooth 72 of the first tooth row 71A on the front side X2 in the tooth engagement portions 65 by a length L1 equivalent to one-half of the pitch P1. The tooth tip 96A of each second tooth 96 of the second tooth row 97B on the rear side X1 is located

in a position that is displaced in the tilt direction C from a position of the tooth tip 72A of the corresponding first tooth 72 of the first tooth row 71B on the rear side X1 in the tooth engagement portions 65 by a length L2 corresponding to one-half of the pitch P2. Hereinafter, the length L1 and the length L2 are also collectively called "length L". The length L does not have to be equivalent to one-half of the pitch P, and only needs to be smaller than the pitch P.

The tooth member 95 is different from the tooth member 66 in having, instead of the third tooth rows 75 of the tooth member 66, fourth tooth rows 99 each including a plurality of fourth teeth 98 that are arranged in the tilt direction C. However, the shapes of the fourth teeth 98 are the same as the shapes of the third teeth 82 of the tooth member 66 that are flipped to the right side Y1 with respect to the reference plane 3D. A tooth tip 98A of each fourth tooth 98 and the tooth tip 82A of the corresponding third tooth 82 are located in the same position in the tilt direction C. Specifically, the position of the tooth tip 98A of each fourth tooth 98 in the fourth tooth row 99A on the front side X2 is the same in the tilt direction C as that of the tooth tip 82A of the corresponding third tooth 82 in the third tooth row 75A on the front side X2 of the tooth member 66. The position of the tooth tip 98A of each fourth tooth 98 in the fourth tooth row 99B on the rear side X1 is the same in the tilt direction C as that of the tooth tip 82A of the corresponding third tooth 82 in the third tooth row 75B on the rear side X1 of the tooth member 66. In other words, the third teeth 82 and the fourth teeth 98 are disposed in the same phase in the tilt direction C.

In the present embodiment, a case is assumed in which the first teeth 72 and the third teeth 82 mesh with each other and the fourth teeth 98 are riding on the second teeth 96 (the state depicted in FIG. 9). In this state, the tooth tip 98A of each fourth tooth 98 and the tooth tip 96A of the corresponding second tooth 96 are displaced from each other in the tilt direction C by the length L equivalent to one-half of the pitch P. In this state, when a force acting in the tilt direction C is generated by an impact caused by a secondary collision, the state in which the first teeth 72 and the third teeth 82 mesh with each other is maintained. Meanwhile, the fourth tooth rows 99 slip off the second tooth rows 97 to be shifted upward in the tilt direction C by a length equivalent to one-half of the pitch P, so that the fourth teeth 98 having been riding on the second teeth 96 mesh with the second teeth 96.

A comparative example is assumed in which the first teeth 72 and the second teeth 96 are disposed in the same phase in the tilt direction C, and the third teeth 82 and the fourth teeth 98 are disposed in the same phase in the tilt direction C. In the comparative example, when a secondary collision occurs in the tooth-on-tooth state, in order for the first teeth 72 and the third teeth 82 to mesh with each other, the third tooth rows 75 need to slip off the first tooth rows 71 to be displaced upward in the tilt direction C by a length equivalent to the pitch P at the maximum. The fourth tooth rows 99 also need to slip off the second tooth rows 97 to be displaced upward in the tilt direction C by a length equivalent to the pitch P at the maximum.

By contrast, when the first teeth 72 and the third teeth 82 mesh with each other and the fourth teeth 98 are riding on the second teeth 96 as in the present embodiment, the fourth teeth 98 are displaced by a length smaller than the pitch P (the length equivalent to one-half of the pitch P in the present embodiment), whereby the second teeth 96 and the fourth teeth 98 can mesh with each other. In this case, the first teeth 72 and the third teeth 82 are displaced from each other and

the second teeth **96** and the fourth teeth **98** are displaced from each other in the tilt direction **C**. Thus, as depicted in FIG. **10A** that is a schematic diagram illustrating a state of the steering system **1** after a secondary collision, the tilt bolt **40** inclines with respect to the right-and-left direction **Y** so that the right end portion **40C** moves to be positioned more toward the upper side **Z1** than the left end portion **40B**. Accordingly, the column jacket **4** supporting the tilt bolt **40** inclines. Consequently, the central axis **4A** of the column jacket **4** moves upward in the tilt direction **C**. In FIG. **10A**, the column jacket **4** and the tilt bolt **40** before inclining are indicated by long dashed double-short dashed lines.

The central axis **4A** is positioned in the substantial center between the left end portion **40B** and the right end portion **40C** of the tilt bolt **40** in the right-and-left direction **Y**. Thus, a length **LC** by which the central axis **4A** moves in the tilt direction **C** is smaller than a length **LR** (also called "slipping length **LR**") by which the right end portion **40C** moves in the tilt direction **C** when the fourth tooth rows **99** are displaced in the tilt direction **C** relatively to the second tooth rows **97**. Specifically, the length **LC** is equivalent to one-half of the length **LR**, that is, one-quarter of the pitch **P**.

Thus, the moving distance of the column jacket **4** when the column jacket **4** moves in the tilt direction **C** in the event of a secondary collision can be reduced. In the present embodiment, the length **L** is equivalent to one-half of the pitch **P**. Thus, the slipping length **LR** can be minimized. Consequently, the moving distance of the column jacket **4** when the column jacket **4** moves in the tilt direction **C** in the event of the secondary collision can be further reduced.

FIG. **10B** is a schematic diagram illustrating a state of the steering system **1** after a secondary collision occurs in a state different from that in FIG. **10A**. In FIG. **10B**, the tilt bolt **40** before the secondary collision occurs is indicated by a long dashed short dashed line. Before the secondary collision, the first teeth **72** and the third teeth **82** ride on each other, and the fourth teeth **98** ride on the second teeth **96**. In FIG. **10B**, the second teeth **96** and the fourth teeth **98** slightly ride on each other.

As seen in FIG. **10B**, in the event of a secondary collision with the steering system **1** being in this state, when the left end portion **40B** and the right end portion **40C** of the tilt bolt **40** both move in the tilt direction **C** by a length equivalent to one-half of the pitch **P** at the maximum, for example, the first teeth **72** and the third teeth **82** mesh with each other. In FIG. **10B**, the tilt bolt **40** at this time is indicated by a long dashed double-short dashed line. At this time, the central axis **4A** of the column jacket **4** has moved in the tilt direction **C** by a length **LC1** equivalent to one-half of the pitch **P** from the original position before the secondary collision. After the first teeth **72** and the third teeth **82** mesh with each other, in order for the second teeth **96** and the fourth teeth **98** to mesh with each other, the tilt bolt **40** and the column jacket **4** incline in the same manner as described above and the central axis **4A** moves in the tilt direction **C** by a length **LC2** equivalent to one-quarter of the pitch **P**.

Thus, when a secondary collision occurs, with the first teeth **72** and the third teeth **82** riding on each other and the fourth teeth **98** riding on the second teeth **96**, the length **LC** by which the central axis **4A** of the column jacket **4** moves in the tilt direction **C** is equal to the sum of the length **LC1** and the length **LC2**. Specifically, the length **LC** is equivalent to three-quarters of the pitch **P** at the maximum. Thus, even in this case, the length **LC** by which the central axis **4A** moves can be reduced. Specifically, in the comparative example, the central axis **4A** moves by a length equivalent to the pitch **P** at the maximum. This means that, in the

present embodiment, the length **LC** by which the central axis **4A** moves can be reduced by about 25% in comparison with the comparative example.

Although not depicted, a case is assumed in which the second teeth **96** and the fourth teeth **98** mesh with each other, and the first teeth **72** and the third teeth **82** ride on each other without meshing with each other (the reverse of the case in FIG. **10A**). In this case, in the event of a secondary collision, the tilt bolt **40** inclines with respect to the right-and-left direction **Y** so as to cause the left end portion **40B** to move to be positioned more toward the upper side **Z1** than the right end portion **40C**. Thus, in the same manner as described above, the moving distance of the column jacket **4** when the column jacket **4** moves in the tilt direction **C** in the event of a secondary collision can be reduced.

The present invention is not limited to the embodiment described above, and various modifications may be made within the scope of the claims. For example, in the embodiment, the first tooth rows **71** are formed integrally with each side plate **30** of the upper bracket **6** as part of the corresponding tooth engagement portions **65** so as to be supported by the upper bracket **6**. Alternatively, the first tooth rows **71** may be formed separately from the side plate **30**. The tooth member **66** having the third tooth rows **75** may be formed integrally with the moving member **43** and the moving member **45**.

Regarding these modifications, the following describes a first modification to a third modification of the tilt locking mechanisms **9**. In the following description, the tilt locking mechanism **9** on the left side **Y2** will be described. The structure of the tilt locking mechanism **9** on the right side **Y1** is the same as that of the tilt locking mechanism **9** on the left side **Y2**. FIG. **11** is an exploded perspective view of a tilt locking mechanism **9** according to the first modification. In FIG. **11** and later-described FIGS. **12** and **13**, members that are the same as the members described in the foregoing are denoted by the same reference characters, and description thereof is omitted.

In the first modification, as a member separated from a side plate **30**, a tooth member **85** is provided. The tooth member **85** is a metal plate that is substantially rectangular when viewed from the right-and-left direction **Y** and is thin in the right-and-left direction **Y**. In the substantial center of the tooth member **85** when viewed from the right-and-left direction **Y**, a guide slot **85A** penetrating the tooth member **85** in the right-and-left direction **Y** is formed. The guide slot **85A** extends along the tilt direction **C**. A pair of first tooth rows **71** are formed integrally with the tooth member **85** so as to rim both sides of the guide slot **85A** in the axial direction **X**. In the same manner as in the embodiment, in each first tooth row **71**, a plurality of first teeth **72** are arranged at regular intervals of the pitch **P** along the tilt direction **C**. Specifically, the first teeth **72** of the first tooth row **71A** on the front side **X2** are arranged at the pitch **P1**. The first teeth **72** of the first tooth row **71B** on the rear side **X1** are arranged at the pitch **P2**.

Tooth tips **72A** of the first teeth **72** of the first tooth row **71A** on the front side **X2** are exposed to the guide slot **85A** toward the rear side **X1**. Tooth tips **72A** of the first teeth **72** of the first tooth row **71B** on the rear side **X1** are exposed to the guide slot **85A** toward the front side **X2**. The first teeth **72** in either row have tooth traces **72B** extending along the right-and-left direction **Y**. On both outer sides of the guide slot **85A** in the axial direction **X** in the tooth member **85**, insertion slots **85B** extending straight along the up-and-down direction **Z** and penetrating the tooth member **85** in the right-and-left direction **Y** are each formed.

19

Insertion slots 30A each having substantially the same shape as that of each insertion slot 85B are each formed on both outer sides of the tilt slot 32 in the axial direction X in the side plate 30 on the left side Y2. The insertion slots 30A extend straight along the up-and-down direction Z and penetrate the side plate 30 on the left side Y2 in the right-and-left direction Y. Along the insertion slots 85B and 30A, a pair of long block-like support members 86 are provided. Projecting portions 86A formed on the left side surfaces of the support members 86 are inserted into the insertion slots 85B from the right side Y1. Projecting portions 86B formed on the right side surfaces of the support members 86 are inserted into the insertion slots 30A from the left side Y2. Consequently, the tooth member 85 is supported by the side plate 30 on the left side Y2 via the support members 86. The tooth member 85 is positioned separated from the side plate 30 on the left side Y2 toward the left side Y2, and the guide slot 85A overlap the tilt slot 32 when viewed from the right-and-left direction Y. The tooth member 85 has elasticity, and thus the first tooth row 71A can elastically deform in the right-and-left direction Y. The support members 86 may be members separated from the side plate 30, or may be formed integrally with the side plate 30.

The tooth member 66 (see FIG. 4) is omitted, and the pair of the third tooth rows 75 in the tooth member 66 are formed on a moving member 43. Thus, in the first modification, the moving member 43 also serves as the tooth member 66. The third tooth rows 75 in this case are formed integrally with the moving member 43 on both side surfaces of a second pressing portion 52 in the axial direction X. In the same manner as in the embodiment, in each third tooth row 75, a plurality of third teeth 82 are arranged at regular intervals of the pitch P along the tilt direction C. Specifically, the third teeth 82 of the third tooth row 75A on the front side X2 are arranged at the pitch P1. The third teeth 82 of the third tooth row 75B on the rear side X1 are arranged at the pitch P2. Tooth tips 82A of the third teeth 82 of the third tooth row 75A on the front side X2 are directed to the front side X2. Tooth tips 82A of the third teeth 82 of the third tooth row 75B on the rear side X1 are directed to the rear side X1. The third teeth 82 in either row have tooth traces 82B extending along the right-and-left direction Y.

This tilt locking mechanism 9 of the first modification may be different in detail from the tilt locking mechanism 9 of the embodiment. For example, in the tilt locking mechanism 9 of the first modification, the boss portion 53 of the moving member 43 is formed in a cylindrical shape, and is inserted into the guide slot 85A of the tooth member 85 and the tilt slot 32 of the side plate 30. The elastic member 67 is a coil spring that is fitted onto the boss portion 53 and the tilt bolt 40, and is inserted into the guide slot 85A and the tilt slot 32. The elastic member 67 is compressed between the second pressing portion 52 of the moving member 43 and the extending portion 34 on the left side Y2 in the lower jacket 23 (see FIG. 3), thereby generating a restoring force described above. In the first modification, the spacer 68 may be omitted.

In the first modification, when the operation member 41 is operated to change the steering system 1 into the locked state, the moving member 43 moves toward the right side Y1 from the released position to the locked position. When the steering system 1 has been changed into the locked state, the second pressing portion 52 of the moving member 43 that has reached the locked position reaches the inside of the guide slot 85A of the tooth member 85, that is, an area between the pair of the first tooth rows 71. In this state, the

20

first teeth 72 of the first tooth row 71A on the front side X2 and the third teeth 82 of the third tooth row 75A on the front side X2 in the moving member 43 mesh with each other alternately arranged in the tilt direction C. The first teeth 72 of the first tooth row 71B on the rear side X1 and the third teeth 82 of the third tooth row 75B on the rear side X1 mesh with each other alternately arranged in the tilt direction C. In this manner, the pair of the first tooth rows 71 and the pair of the third tooth rows 75 intermesh with each other.

When the operation member 41 is operated in the opposite direction to change the steering system 1 from the locked state into the released state, the moving member 43 moves from the locked position toward the left side Y2 and reaches the released position. At this time, by the restoring force of the elastic member 67, movement of the moving member 43 to the released position is facilitated. When the steering system 1 has been changed into the released state, the third tooth rows 75 move toward the left side Y2 relatively to the first tooth row 71, so that the intermeshing between the third tooth rows 75 and the first tooth rows 71 is released.

When the operation member 41 is operated to change the steering system 1 into the locked state with the third tooth rows 75 riding on the first tooth rows 71, the first tooth rows 71A are pressed by the third tooth rows 75 to elastically deform toward the side plate 30 on the left side Y2. Thus, the steering system 1 is changed into the tooth-on-tooth state. The shapes of the respective members of the tilt locking mechanism 9 on the right side Y1 are substantially the same as the shapes of the respective members of the tilt locking mechanism 9 on the left side Y2 that are flipped to the right side Y1 with respect to the reference plane 3D. The operation of the tilt locking mechanism 9 on the right side Y1 is almost the same as the operation of the tilt locking mechanism 9 on the left side Y2 except that the right-and-left orientation is reversed. In the first modification also, in the same manner as in the present embodiment depicted in FIG. 9, either one pair, out of a pair of the tooth tip 72A of each first tooth 72 and the tooth tip 96A of the corresponding second tooth 96 and a pair of the tooth tip 82A of each third tooth 82 and the tooth tip 98A of the corresponding fourth tooth 98, are located in the same position in the tilt direction C. The other pair may be displaced from each other by the length L that is smaller than the pitch P in the tilt direction C. This displacement exerts the same effect as in the present embodiment.

FIG. 12 is an exploded perspective view of a tilt locking mechanism 9 according to the second modification. The tilt locking mechanism 9 according to the second modification is different in detail from the tilt locking mechanism 9 according to the first modification. Specifically, in the tilt locking mechanism 9 according to the second modification, a pair of first tooth rows 71 are not positioned so as to rim a guide slot 85A, but are formed integrally with a tooth member 85 on its both side edges in the axial direction X. In each first tooth row 71, a plurality of first teeth 72 are arranged at regular intervals of the pitch P along the tilt direction C. Specifically, the first teeth 72 of the first tooth row 71A on the front side X2 are arranged at the pitch P1. The first teeth 72 of the first tooth row 71B on the rear side X1 are arranged at the pitch P2. Tooth tips 72A of the first teeth 72 of the first tooth row 71A on the front side X2 are directed to the front side X2. Tooth tips 72A of the first teeth 72 of the first tooth row 71A on the rear side X1 are directed to the rear side X1. The first teeth 72 in either row have tooth traces 72B extending along the right-and-left direction Y.

In the second modification, both end portions of a first pressing portion 51 of a moving member 43 in the axial

21

direction X are, as bent portions 51B, bent toward the right side Y1. The bent portions 51B are formed in a pair and face each other in the axial direction X. In the moving member 43, third tooth rows 75 are not formed on both side surfaces of a second pressing portion 52 in the axial direction X, but are integrally formed each on the respective facing surfaces of the pair of bent portions 51B. In each third tooth row 75, a plurality of third teeth 82 are arranged at regular intervals of the pitch P along the tilt direction C. Specifically, the third teeth 82 of the third tooth row 75A on the front side X2 are arranged at the pitch P1. The third teeth 82 of the third tooth row 75B on the rear side X1 are arranged at the pitch P2. Tooth tips 82A of the third teeth 82 of the third tooth row 75A on the front side X2 are directed to the rear side X1. Tooth tips 82A of the third teeth 82 of the third tooth row 75B on the rear side X1 are directed to the front side X2. The third teeth 82 in either row have tooth traces 72B extending along the right-and-left direction Y.

In the second modification, when the operation member 41 is operated to change the steering system 1 into the locked state, the moving member 43 moves toward the right side Y1 from the released position to the locked position. When the steering system 1 has been changed into the locked state, the second pressing portion 52 of the moving member 43 that has reached the locked position reaches the inside of the guide slot 85A of the tooth member 85, and the pair of the bent portions 51B of the first pressing portion 51 of the moving member 43 catch the tooth member 85 from both sides in the axial direction X. In this state, the first teeth 72 of the first tooth row 71A on the front side X2 in the tooth member 85 and the third teeth 82 of the third tooth row 75A on the front side X2 in the moving member 43 mesh with each other alternately arranged in the tilt direction C. The first teeth 72 of the first tooth row 71B on the rear side X1 and the third teeth 82 of the third tooth row 75B on the rear side X1 mesh with each other alternately arranged in the tilt direction C. Thus, the pair of the first tooth rows 71 and the pair of the third tooth rows 75 intermesh with each other.

When the operation member 41 is operated in the opposite direction to change the steering system 1 from the locked state into the released state, the intermeshing between the third tooth rows 75 and the first tooth rows 71 is released in the same manner as in the first modification. In the second modification also, the steering system 1 can be in the tooth-on-tooth state in the same manner as in the first modification. The shapes of the respective members of the tilt locking mechanism 9 on the right side Y1 are substantially the same as the shapes of the respective members of the tilt locking mechanism 9 on the left side Y2 that are flipped to the right side Y1 with respect to the reference plane 3D. The operation of the tilt locking mechanism 9 on the right side Y1 is almost the same as the operation of the tilt locking mechanism 9 on the left side Y2 except that the right-and-left orientation is reversed. In the second modification also, in the same manner as in the present embodiment depicted in FIG. 9, either one pair, out of a pair of the tooth tip 72A of each first tooth 72 and the tooth tip 96A of the corresponding second tooth 96 and a pair of the tooth tip 82A of each third tooth 82 and the tooth tip 98A of the corresponding fourth tooth 98, are located in the same position in the tilt direction C, and the other pair may be displaced from each other by the length L that is smaller than the pitch P in the tilt direction C. This displacement exerts the same effect as in the present embodiment.

FIG. 13 is an exploded perspective view of a tilt locking mechanism 9 according to the third modification. In the third modification, as members separated from the side plate 30,

22

a first tooth member 88 and a second tooth member 89 are provided. The first tooth member 88 is a metal plate that is substantially rectangular when viewed from the right-and-left direction Y and is thin in the right-and-left direction Y. In the substantial center of the first tooth member 88 when viewed from the right-and-left direction Y, a guide slot 88A penetrating the first tooth member 88 in the right-and-left direction Y is formed. The guide slot 88A extends straight along the tangential direction to the tilt direction C, that is, the up-and-down direction Z. The guide slot 88A is narrower than the tilt slot 32 in the axial direction X. Into the guide slot 88A, the tilt bolt 40 is inserted.

In the left side surface of the side plate 30 on the left side Y2, on both outer sides of the tilt slot 32 in the up-and-down direction Z, rib-like guide portions 90 that protrude toward the left side Y2 and extend straight along the axial direction X are integrally formed. The first tooth member 88 is disposed between the upper and lower guide portions 90, and is supported by the side plate 30 via these guide portions 90. The first tooth member 88 can slide in the axial direction X along the guide portions 90, but cannot move in directions other than the axial direction X. In the left side surface of the side plate 30 on the left side Y2, on both outer sides of the tilt slot 32 in the axial direction X, reception grooves 91 that are recessed toward the right side Y1 and extend parallel to the tilt slot 32 are each formed.

A pair of first tooth rows 71 are formed integrally with the first tooth member 88 on its both side edges in the axial direction X. Unlike the embodiment, the first modification, and the second modification, in each first tooth row 71 in the third modification, a plurality of first teeth 72 are arranged straight at regular intervals of the pitch P along the up-and-down direction Z. Tooth tips 72A of the first teeth 72 of the first tooth row 71A on the front side X2 are directed to the front side X2. Tooth tips 72A of the first teeth 72 of the first tooth row 71A on the rear side X1 are directed to the rear side X1. The first teeth 72 in either row have tooth traces 72B extending along the right-and-left direction Y.

The second tooth member 89 is formed in a block-like shape that is long in the axial direction X and is thin in the right-and-left direction Y, and is disposed closer to the left side Y2 than the first tooth member 88. In the substantial center of the second tooth member 89 in the axial direction X, a fitting hole 89A penetrating the second tooth member 89 in the right-and-left direction Y is formed. The fitting hole 89A corresponds to a first pressing portion 51 of a moving member 43 when viewed from the right-and-left direction Y, and the first pressing portion 51 is fitted into the fitting hole 89A from the left side Y2. Accordingly, the second tooth member 89 is integrated into the moving member 43.

Both end portions of the second tooth member 89 in the axial direction X are, as bent portions 89B, bent toward the right side Y1. The bent portions 89B are formed in a pair and face each other in the axial direction X. The third tooth rows 75 are integrally formed each on the respective facing surfaces of the pair of the bent portions 89B. Tooth tips 82A of the third teeth 82 of the third tooth row 75A on the front side X2 are directed to the rear side X1, and tooth tips 82A of the third teeth 82 of the third tooth row 75A on the rear side X1 are directed to the front side X2. The third teeth 82 in either row have tooth traces 72B extending along the right-and-left direction Y. In each third tooth row 75 in the third modification, in the same manner as in the first tooth row 71, the third teeth 82 are arranged straight at regular intervals of the pitch P along the up-and-down direction Z.

The tilt locking mechanism 9 of the third modification may be different in detail from the tilt locking mechanism 9

of the embodiment. For example, in the tilt locking mechanism 9 of the third modification, the second pressing portion 52 of the moving member 43 has a substantially rectangular profile when viewed from the right side Y1. A boss portion 53 of the moving member 43 is formed in a cylindrical shape. The second pressing portion 52 is fitted into the guide slot 88A of the first tooth member 88. In this state, the moving member 43 can slide along the up-and-down direction Z, but cannot move in the other directions.

An elastic member 67 is a leaf spring that is substantially rectangular when viewed from the right-and-left direction Y, and curves so as to bulge toward the left side Y2. In the center of the elastic member 67 when viewed from the right-and-left direction Y, a fitting hole 67A that is substantially rectangular is formed. On four corners of the substantially rectangular elastic member 67, claw-like engagement portions 67B bending and extending toward the left side Y2 are each integrally formed. The engagement portions 67B engage with the second tooth member 89. Accordingly, the elastic member 67 is positioned on the second tooth member 89. The second pressing portion 52 is fitted into the fitting hole 67A. Accordingly, the elastic member 67 is positioned on the moving member 43. The elastic member 67 is compressed between the first tooth member 88 and the second tooth member 89. This generates the restoring force. In the third modification, the spacer 68 may be omitted.

In the third modification, when the operation member 41 is operated to change the steering system 1 into the locked state, the moving member 43 moves together with the second tooth member 89 toward the right side Y1 from the released position to the locked position. When the moving member 43 has reached the locked position to change the steering system 1 into the locked state, the pair of the bent portions 89B of the second tooth member 89 catch the first tooth member 88 from both sides in the axial direction X.

In this state, the first teeth 72 of the first tooth row 71A on the front side X2 in the first tooth member 88 and the third teeth 82 of the third tooth row 75A on the front side X2 in the second tooth member 89 mesh with each other alternately arranged in the up-and-down direction Z. The first teeth 72 of the first tooth row 71B on the rear side X1 and the third teeth 82 of the third tooth row 75B on the rear side X1 mesh with each other alternately arranged in the up-and-down direction Z. Thus, the pair of the first tooth rows 71 and the pair of the third tooth rows 75 intermesh with each other.

When the operation member 41 is operated in the opposite direction to change the steering system 1 from the locked state into the released state, the moving member 43 moves together with the second tooth member 89 from the locked position toward the left side Y2 and reaches the released position. At this time, by the restoring force of the elastic member 67, movement of the moving member 43 and the second tooth member 89 to the released position is facilitated. When the steering system 1 has been changed into the released state, the third tooth rows 75 have moved to be positioned more toward the left side Y2 than the first tooth row 71. This releases the intermeshing between the third tooth rows 75 and the first tooth rows 71. In this state, when the column jacket 4 is tilted, the second tooth member 89 pivots on the circular-arc-like trajectory along the tilt direction C together with the tilt bolt 40. At this time, the second tooth member 89 moves relatively to the first tooth member 88 in the up-and-down direction Z, and moves integrally therewith in the axial direction X. Thus, the first tooth rows 71 are always disposed at the same positions as those of the corresponding third tooth rows 75 in the axial direction X.

Consequently, even if the first tooth rows 71 and the third tooth rows 75 do not extend in a circular-arc-like manner along the tilt direction C but extend straight along the up-and-down direction Z unlike the embodiment, the first modification, and the second modification, the first tooth rows 71 and the third tooth rows 75 can reliably mesh with each other after tilt adjustment.

When the operation member 41 is operated to change the steering system 1 into the locked state with the third tooth rows 75 riding on the first tooth rows 71, the first tooth rows 71 elastically deform toward the side plate 30 on the left side Y2 and are received by the reception grooves 91 of the side plate 30 on the left side Y2. Thus, the steering system 1 is changed into the tooth-on-tooth state. The shapes of the respective members of the tilt locking mechanism 9 on the right side Y1 are substantially the same as the shapes of the respective members of the tilt locking mechanism 9 on the left side Y2 that are flipped to the right side Y1 with respect to the reference plane 3D. The operation of the tilt locking mechanism 9 on the right side Y1 is almost the same as the operation of the tilt locking mechanism 9 on the left side Y2 except that the right-and-left orientation is reversed. In the third modification also, in the same manner as in the present embodiment depicted in FIG. 9, either one pair, out of a pair of the tooth tip 72A of each first tooth 72 and the tooth tip 96A of the corresponding second tooth 96 and a pair of the tooth tip 82A of each third tooth 82 and the tooth tip 98A of the corresponding fourth tooth 98, are located in the same position in the tilt direction C, and the other pair may be displaced from each other by the length L that is smaller than the pitch P in the tilt direction C. This displacement exerts the same effect as in the present embodiment.

The present invention can be applied not only to the embodiment and the first modification to the third modification, but also to any tilt locking mechanism 9 in which tooth traces 72B of first teeth 72 and tooth traces 82B of third teeth 82 extend in a right-and-left direction Y parallel to the central axis 40A of a tilt bolt 40. Thus, the present invention can be applied also to the teeth of the holding unit and the tooth plate in the steering column described in US 2009/0013817 A1. A plurality of third teeth 82 are arranged along the tilt direction C, for example, to constitute a third tooth row 75, but the tooth row does not have to be constituted. The essential thing is that the third tooth 82 only needs to be formed at least one in each of two locations spaced apart from each other in the axial direction X, which can mesh a first tooth row 71. In the same manner, a plurality of fourth teeth 98 are arranged along the tilt direction C, for example, to constitute a fourth tooth row 99, but the tooth row does not have to be constituted. The essential thing is that the fourth tooth 98 only needs to be formed at least one in each of two locations spaced apart from each other in the axial direction X, which can mesh with a second tooth row 97.

Unlike the present embodiment or the first modification to the third modification, the tooth tip 72A of each first tooth 72 and the tooth tip 96A of the corresponding second tooth 96 may be located in the same position in the tilt direction C, and the tooth tip 82A of each third tooth and the tooth tip 98A of the corresponding fourth tooth 98 may be displaced from each other in the tilt direction C. Even in this structure, the same effect as in the present embodiment can be exerted. The tilt locking mechanism 9 may be provided on either one of the right side Y1 and the left side Y2 of the upper bracket 6.

The steering system 1 is not limited to a manual-type steering system that does not assist steering operation of the steering member 11. The steering system 1 may be a

25

column-assist-type electric power steering system that assists steering operation of the steering member **11** with an electric motor. The tilt locking mechanism **9** can also be applied to a steering system that does not have the telescopic locking mechanism **8**, and to a steering system in which telescopic adjustment cannot be performed.

The tilt locking mechanism **9** can also be applied to a steering system **1** in which the connecting plate **31** (see FIG. **2**) of the upper bracket **6** and the vehicle body **2** (see FIG. **1**) are coupled together by capsules (not depicted). In a secondary collision, resin pins (not depicted) that are inserted through both of the capsules and the connecting plate **31** are broken, which causes the upper bracket **6** to be detached from the vehicle body **2**.

The lower jacket **23** only needs to hold the upper jacket **22** as being clamped by a pair of side plates **30** to be reduced in diameter. For example, the end of the slit **33** (see FIG. **2**) on the front side **X2** may be closed. The steering system **1** may have, instead of the lower jacket **23**, a structure of holding the upper jacket **22** without being reduced in diameter.

What is claimed is:

1. A steering system comprising:

- a steering shaft to one end of which a steering member is coupled;
- a column jacket that holds the steering shaft, has a central axis along an axial direction of the steering shaft, and is movable in an intersecting direction vertically intersecting the axial direction;
- a bracket that is fixed to a vehicle body, the bracket including a pair of side plates disposed so as to face each other in an orthogonal direction orthogonal to the intersecting direction and the axial direction, and the bracket supporting the column jacket so that the column jacket is movable between the pair of side plates;
- an insertion shaft extending in the orthogonal direction having a tilt locking mechanism located at each outer side of each of the pair of side plates in the orthogonal direction, the tilt locking mechanism (i) being attached

26

to the insertion shaft and configured to allow and prevent movement of the column jacket with respect to the bracket, and (ii) being movable together with the column jacket in the intersecting direction;

- a first tooth row supported by one of the side plates, the first tooth row including a plurality of first teeth arranged at a predetermined pitch in the intersecting direction;
 - a second tooth row, symmetrical to the first tooth row and mirrored across the central axis along the axial direction of the steering shaft, that is supported by another one of the side plates, the second tooth row including a plurality of second teeth arranged at a predetermined pitch in the intersecting direction;
 - a third tooth configured to mesh with the first teeth, supported by one end portion of the end portions of the insertion shaft, and configured to come into and out of contact with the first tooth row in accordance with operation of an operation member; and
 - a fourth tooth configured to mesh with the second teeth, supported by the other end portion of the insertion shaft, and configured to come into and out of contact with the second tooth row in accordance with operation of the operation member, wherein:
 - a tooth tip of one of the plurality of first teeth of the first tooth row, and a tooth tip of a corresponding one of the plurality of second teeth of the second tooth row, are displaced from each other by a length that is smaller than a predetermined pitch in the intersecting direction; and
 - a tooth tip of one of the plurality of third teeth of the third tooth row, and a tooth tip of a corresponding one of the plurality of fourth teeth of the fourth tooth row, are located in an identical position in the intersecting direction.
- 2.** The steering system according to claim **1**, wherein the length is equivalent to one-half of the predetermined pitch.

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